A Comparative Study between Dry Needling Verses Shockwave Therapy on Peroneal Trigger Points in Patients with a History of Chronic Inversion Ankle Sprain

A research dissertation presented to the Faculty of Health Sciences, University of Johannesburg, as partial fulfilment for the Master's degree in Technology, Chiropractic by

Robyn Miller

(Student number: 201423254)

Supervisor: _____ 20-01-2020

Dr. C Hay Date

Co-supervisor: _____ 20-01-2020

Dr. F Ismail Date

Declaration

I declare that this dissertation is my own, unaided work. It is being submitted for partial fulfillment for the Master's Degree in Technology, in the program of Chiropractic, at the University of Johannesburg. It has not been submitted before for any degree or examination in any other Technikon or University.

_____

Robyn Miller

20 day of January 2020.

Dedication

I dedicate this dissertation to my parents, Lynette and Norman Miller, who have always been positive role models in my life. Thank you for raising me to be the strong minded, level headed and motivated woman I am today. You guys taught me the importance of hard work, integrity and never giving up. Without you none of this would have been possible.

To my brother and sister, Kerry and Shayne Miller for your continuous love and support.

To my best friend Claudia Rabim, for always being my shoulder to cry on and keeping me sane throughout this process. Thank you for always being patient with me and pushing me to do my best. You have been my greatest motivation.

To Chagan Kruger, for always believing in me and giving me the longest hugs when I needed them. I know you are still supporting me, just from up in heaven now.

To the rest of my friends and family, for all that you have done for me and for your continued support throughout this journey.

Lastly to my chiro family, we have endeavoured through these six years together and finally finished strong.

Acknowledgements

I would like to express my deepest appreciation and respect to my supervisor and co-supervisor, Dr Hay and Dr Ismail thank you for all your time, guidance and knowledge that you have shared with me throughout this process.

A huge thank you goes to all who participated in this research. Without you this study would not have been possible.

To Jaclyn de Klerk at STATKON, thank you for all your time, assistance, advice and guidance in helping me with my statistical analysis.

To Dr Yelverton, all my lecturers and clinicians alike, thank you for sharing your knowledge with me throughout the six years of my studies. You have shaped my academic career into a prosperous future.

Abstract

Purpose: The aim of this study was to explore the comparative effects of two different soft tissue approaches in the treatment of active peroneal trigger points. The data from the two different groups was analyzed to establish which soft tissue approach was the most effective in the treatment of active peroneal trigger points in a patient with a history of a chronic inversion ankle sprain.

Method: This clinical trial was a quantitative, randomized study that was comparative in nature, of which 30 male and female participants between the ages 18 to 35 years old were recruited. This study used the stratification method of randomization according to age and gender. Upon meeting the criteria, participants were divided as they were recruited into two smaller groups of fifteen. Group A received dry needling while group B received shockwave therapy to the most active trigger point in the peroneal muscle group on the side of the chronic inversion ankle sprain. Treatment sessions were carried out over three weeks on alternate days with treatment proceeding on days 1 through 6. Perceived pain was measured using the NPRS, tenderness of the most active peroneal trigger point was measured using the pressure algometer and ankle range of motion was measured using the goniometer on visits 1, 4 and 7.

Results: The analysis of Numerical Pain Rating Scale revealed a statistical significance. This indicates that both groups have significance clinically, as both groups were effective in decreasing perceived pain. As was the case with the analysis of the pain pressure algometer readings, both groups revealed a statistical significance, indicating that both groups have significance clinically, as both groups were effective in decreasing pain threshold. However, neither group showed a superior result in reducing perceived pain and pain threshold. As for range of motion, dry needling proved to have a clinical significance as group A yielded the superior results, showing an increase in ankle dorsiflexion, plantarflexion and inversion. Contrary, shockwave therapy proved to be clinically insignificant as there was only an increase in ankle inversion noted.

Conclusion: To conclude, both treatment protocols were effective in reducing pain of the active peroneal trigger point. However, dry needling showed to be more effective than shockwave therapy in improving the overall range of motion of the ankle of participants who have a history of a chronic inversion ankle sprain.

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List of Abbreviations

CAI: Chronic ankle instability

ATP: Adenosine triphosphate

ADP: Adenosine diphosphate

TA: Tibialis longus

PL: Peronius longus

PB: Peronius brevis

CGRP: Calcitonin gene-related peptide

ACh: Acetylcholine

AChE: Acetylcholine Esterase

nAChRs: Nicotinic acetylcholine receptors

AChR: Acetylcholine receptors

MTrPs: Myofascial Trigger Points

ESWT: Extracorporeal shockwave therapy

NPRS: Numerical pain rating scale

SD: Standard deviation

ROM: Range of motion

PPA: Pain Pressure Algometer

PPT: Pain pressure threshold

TrPDN: Trigger point dry needling

MFPs: Myofascial pain syndrome

EWSL: Extrocorporeal shockwave lithotrips

CHAPTER 1 - INTRODUCTION

1.1 Problem Statement

Ankle injuries are amongst the most common musculoskeletal injuries involving sportsmen and woman, with a high recurrence rate of up to 70 percent of lateral ankle ligament injuries. Lateral ankle ligament sprains involve 85 percent of all ankle sprains while eversion sprains of the deltoid ligament comprise 5 percent of sprains and syndesmosis sprains comprise 10 percent of these injuries (Richie, 2001). Most often the mechanism of injury is a sudden shift in the body's centre of gravity, which results from a combination of inversion and adduction of the foot in a plantarflexed position (supination) causing the bodies centre of gravity to roll over the ankle (Dearden, Reeve & Sharpe, 2018). The ankle evertor muscles such as peroneus longus and peroneus brevis play a significant role in protecting the ligamentous tissue from injury, therefore the eccentric contraction of these muscles aid in dynamic support of the lateral ligaments of the ankle (Knight & Weimar, 2011).

When the ankle is placed into a rapid inversion force, the muscle spindles within the peroneal muscles become activated and result in a reflexive contraction of the peroneus longus and peroneus brevis muscles respectively. This reflexive contraction is essential to counteract the effect of excess stretching associated with forced inversion of the ankle (Knight *et al*., 2011). This reflexive contraction of the peroneal longus and brevis muscle most often results in trigger point formation, as an acute onset of myofascial trigger points is often associated with an accident or fall, when specific muscles are overloaded by lengthening contractions used to cushion the impact (Simons, Travell & Simons, 1999).

The rate of ankle re-injury is 28.3 percent and could lead to a condition known as chronic ankle instability (CAI), which could be described as repetitive ankle sprains and persistence of the symptoms after injury (Pietrosimone & Gribble, 2012). Chronic ankle instability can be classified according to their contributing factors, such as mechanical ankle instability and functional ankle instability, which are made up of numerous insufficiencies that lead to each type of instability. Mechanical insufficiencies involve pathologic ligament laxity, impaired arthrokinematics, and synovial and degenerative changes. However, functional insufficiencies involve impaired proprioception, altered neuromusculature control, strength deficits and diminished postural control. The two types of instabilities may occur in isolation, however researchers believe that a combination of the two is the most likely contributing factor leading to chronic ankle instability (Hubbard, Kramer, Denegar & Hertel, 2007).

Ankles of patients that have experienced trauma may have an increased susceptibility of developing osteoarthritis if left untreated with inadequate rehabilitation. It is still uncertain as to which treatment approach is more effective in the treatment of chronic ankle injuries. Granted that there are many types of treatments approaches readily available, there is insufficient evidence on the effectiveness of these treatment approaches for chronic ankle injuries (van Ochten, van Middelkoop, Meuffels & Bierma-Zeinstra, 2014).

In this research, the two treatment approaches that were used were dry needling and shockwave therapy on the treatment of active peroneal myofascial trigger points in chronic lateral ankle sprains.

1.1 Aim

The aim of this study was to explore the comparative effects of two different soft tissue approaches in the treatment of active peroneal trigger points. The data from the two different groups was analyzed to establish which soft tissue approach was the most effective in the treatment of active peroneal trigger points in a patient with a history of a chronic inversion ankle sprain.

1.2 Benefits of the Study

The benefits of this particular study was to gain knowledge to help aid patients who have previously experienced ankle trauma, in ensuring that they have optimal functioning of the peroneal muscle group, with no associated pain from referring myofascial trigger points, as well as possibly improve range of motion in the ankle joint.

The results of this study would be of benefit to further the understanding of ankle injuries, aid other practitioners in the approach to treating ankle injuries as well as contribute to the correct rehabilitation protocol for ankle injuries and to reduce the period of recovery. The result of this study could benefit sport practitioners by exploring the efficacy of dry needling or shockwave therapy on peroneal myofascial trigger points in the previous injured ankles.

Determining the optimal treatment approach for the treatment of previously injured ankles may result in a reduction in recovery time and an improved range of motion. This study could aid future research in preventing recurrent ankle injuries as well as, decrease the prevalence of ankle instability associated with ankle trauma.

CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

The ankle joint has been considered one of the most common joints of the body which experiences trauma during sporting activities, accounting for 10 to 30 percent of all sport related injuries (Fong, Hong, Chan, Yung & Chan, 2007). More often than not the mechanism of injury involves inversion of the foot resulting in injury to the lateral ligaments of the ankle. However, with an eversion injury, damage to the deltoid ligaments would occur, and with a hyperdorsiflexion injury, damage to the syndesmotic ligaments would occur (Golanó, Vega, de Leeuw, Peter, Malagelada, Manzanares, Götzens & van Dijk, 2010).

2.1 Tissue Level of Organization of the Human Body

The human body consists of trillions of cells, which due to differentiation, produces about two hundred types of cells. These cells must co-ordinate their function and work together to form tissues. There are four types of histological tissues, namely epithelial, connective, muscle and neural tissue. Epithelial tissue is the tissue that lines internal passages, covers exposed surfaces and forms glands. Connective tissue is responsible for forming support structures for other tissues, transportation of materials throughout the body, fills internal spaces and stores energy reserves. Muscular tissue includes skeletal, cardiac and smooth muscles, which are specialized tissue that allow for contraction to occur. Neural tissue is responsible for the conduction of an electrical impulse from one part of the body to another in order to relay information (Martini, Nath & Bartholomew, 2014). Neural tissue and skeletal muscle have been looked at in more intricate detail for this dissertation.

2.1.1 Skeletal muscle

Skeletal muscles function as organs of locomotion as well as provide tone that is responsible for static support of the human body. They are made up of a contractile portion (one or more heads or bellies) and a non-contractile portion (tendons). The heads or bellies of the muscle are composed of striated muscle fibres, the tendons are composed of organized collagen bundles and act as an attachment site of muscles to bones. Muscles are categorized according to their shape, which consist of flat, pennate, fusiform, convergent, quadrate, circular and multiheaded. Flat muscle is composed of parallel fibres usually with an aponeurosis attached. Pennate muscle fascicles are arranged in a feather-like pattern and could be bipennate or mulitpennate. Fusiform muscles are usually spindle shaped with a thick belly

and tapered ends. Convergent muscles arise from a broad area and converge to form a single tendon. Quadrate muscles are composed of four equal sides with tendinous attachments on either side. Circular muscles surround an orifice usually opening or closing the opening. Mulitheaded muscles normally contain more than one contractile belly (Moore, Dalley & Agur, 2010).

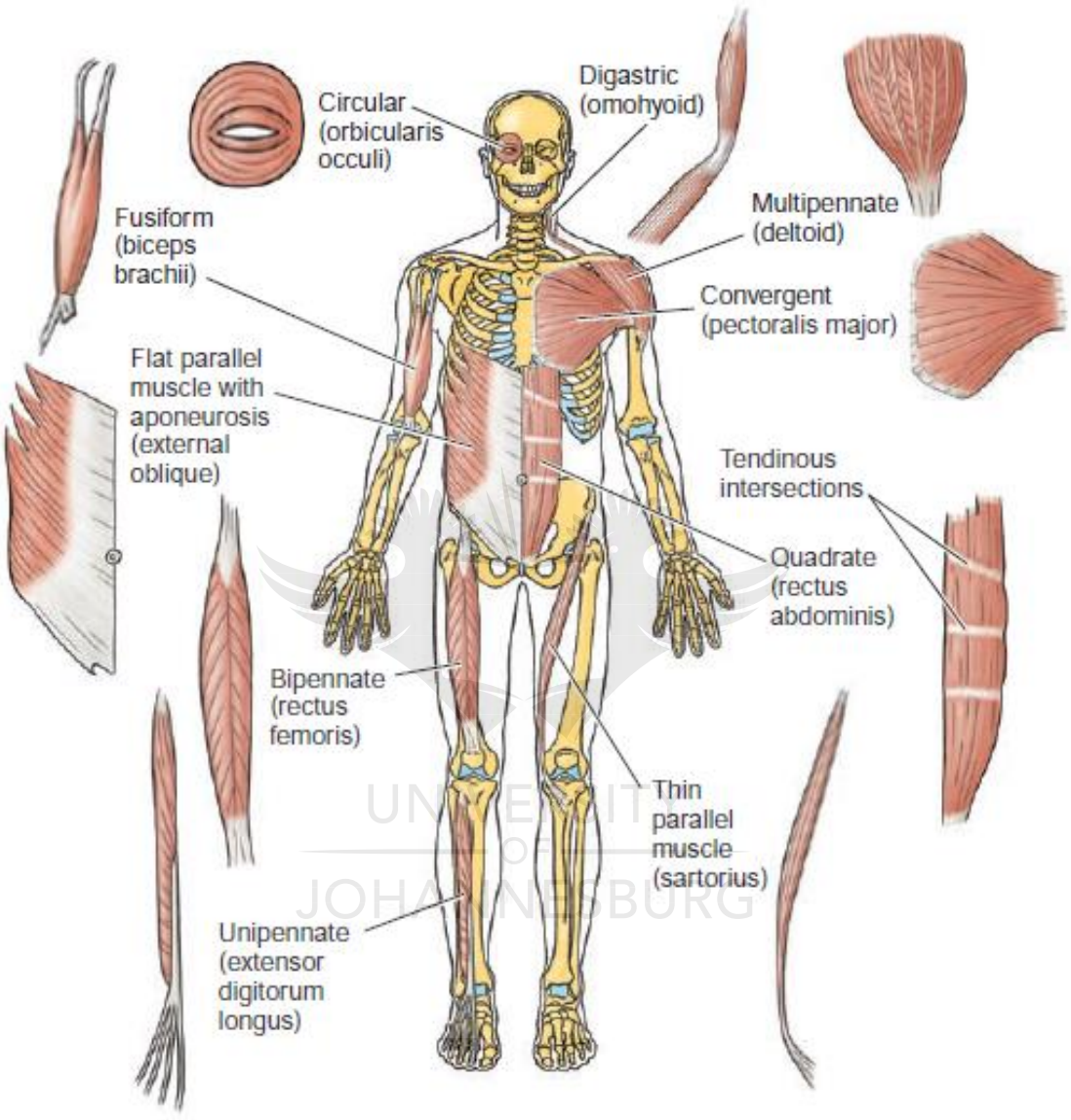


Figure 2.1: Shapes of skeletal muscles (Moore *et al*., 2010)

2.1.2 Neural tissue

Nervous tissue is a specialized tissue for the conduction of electrical impulses throughout the body. Two basic cell types form the basis of nerve tissue, neurons and supporting cells called neuroglia. Communication between neurons involves the formation of an electrical impulse in the form of changes in transmembrane potentials (Martini *et al*., 2014).

2.2 Anatomy of Skeletal Muscle

Skeletal muscle consists of three layers of connective tissue namely the epimysium, perimysium and the endomysium. The epimysium is a dense layer of collagen fibers that surrounds the muscle in its entirety. It functions in separating the muscle from the surrounding tissue and organs. The perimysium divides the muscle into compartments that contain bundles of muscle fibers known as fascicles. The perimysium is a highly vascularized and innovated layer that supplies the muscle fibers within the fascicles. The endomysium is the connective tissue layer within the fascicle that surrounds the individual muscle cells known as muscle fibers. The endomysium contains capillary networks, myosatellite cells which are responsible for the repair of damaged muscle tissue and nerve fibers that aid in muscle control. At either end of the belly of the muscle the epimysium, perimysium and endomysium come together to form a bundle known as a tendon or a broad sheet known as an aponeurosis. The function of the tendons or the aponeurosis is to connect the muscle to bone. When a muscle contracts, shortening of the muscle fibres result in the tendon or aponeurosis to pull on the bone thus movement of a joint is possible (Martini *et al*., 2014).

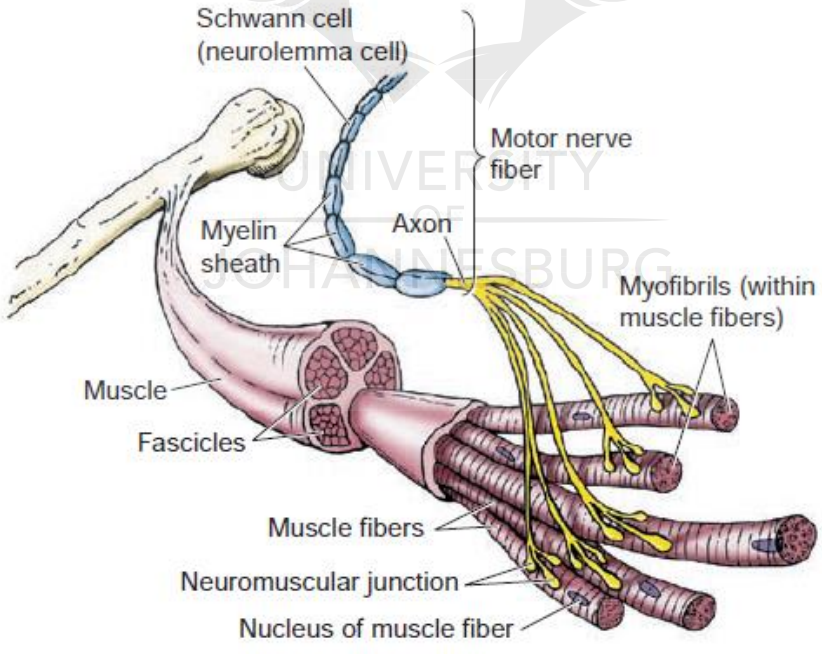


Figure 2.2: Anatomy of a skeletal muscle (Moore *et al*., 2010)

2.2.1 Peroneal muscle anatomy

Peroneus longus lies superficial to peroneus brevis, both of these muscles are located within the lateral compartment of the lower leg. Peroneus longus attaches proximally to the head and superior two thirds of the lateral surface of the fibula and attached distally to the base of the first metatarsal and medial cuneiform. Peroneus brevis is deep to peroneus longus, and is attached proximally to the inferior two thirds of the lateral surface of the fibula and attached distally to the dorsal surface of the tuberosity on the lateral side of the base of the fifth metatarsal. These muscles evert the foot and weakly plantar flex the ankle, and are both supplied by the superficial fibula nerve (L5, S1, S2) (Moore *et al*., 2010).

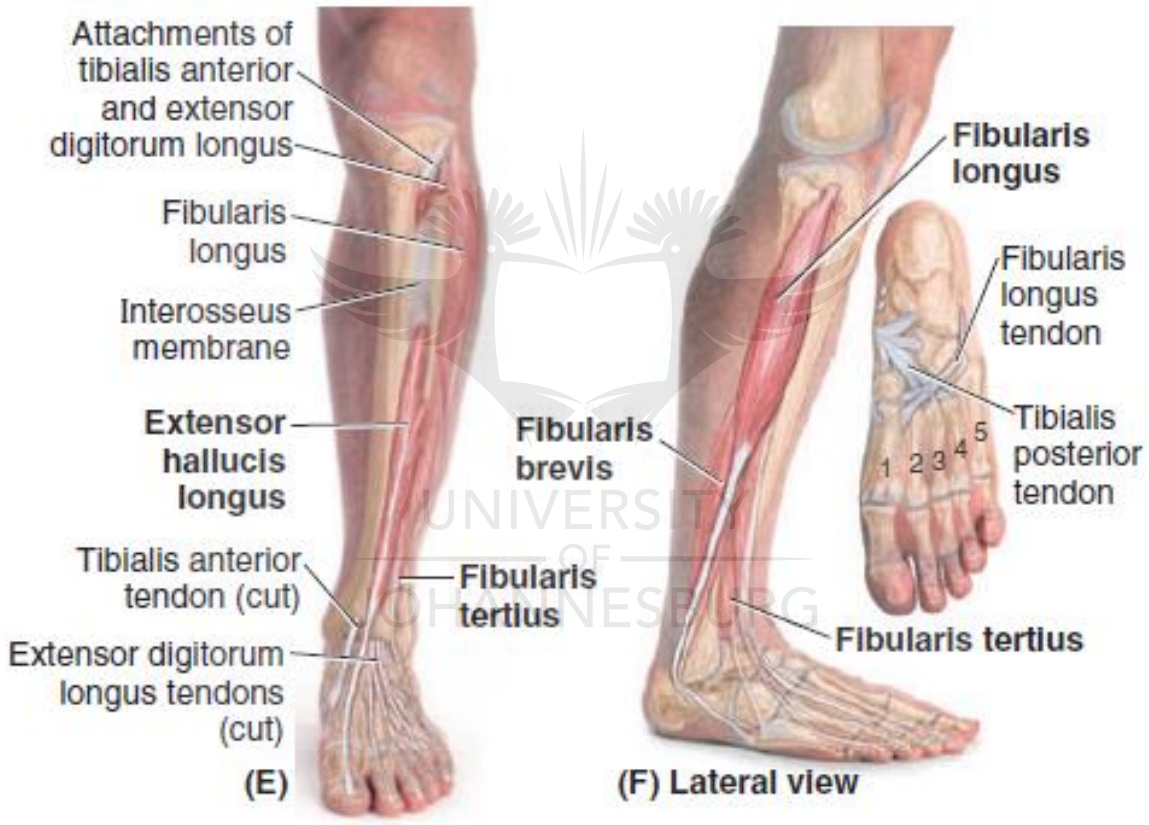


Figure 2.3: Peroneal muscle anatomy (Moore *et al*., 2010)

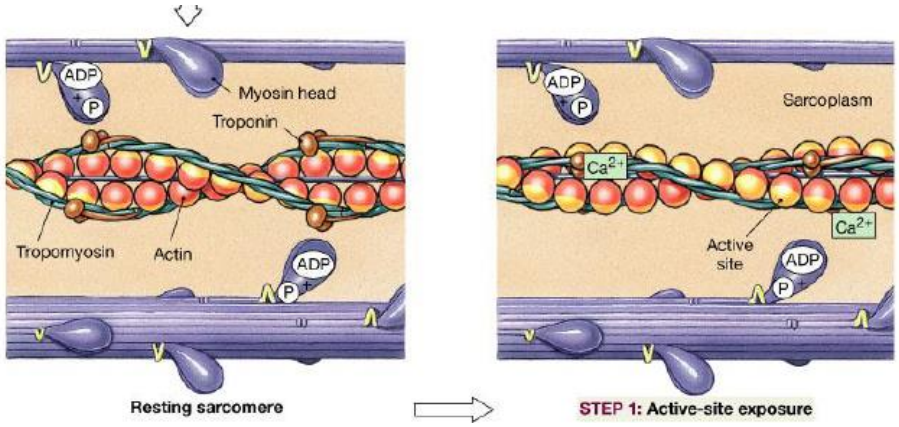
2.2.2 Skeletal muscle contraction formation

Skeletal muscle fibres produces a contraction when stimulated by a motor neuron at the neuromuscular junction, this stimulus arrives in the form of an action potential at the synaptic terminal. The arrival of the action potential at the synaptic terminal in turn results in the release of acetylcholine molecules into the synaptic cleft. The acetylcholine molecules diffuse to the motor end plate, where it binds to the

receptors. This influx of acetylcholine across the motor end plate results in the opening of the sodium ion channels, which thus results in the formation of an action potential in the sarcolemma. The action potential in the sarcolemma travels along the T tubules to reach the triads, where it stimulates the release of calcium ions from the terminal cisternae of the sarcoplasmic reticulum. Thus the contraction cycle begins and continues until the adenosine triphosphate (ATP) supply runs out (Martini *et al*., 2014).

The calcium ions bind to the troponin causing the bonds between actin and troponin-tropomyosin complex to weaken. Resulting in the troponin to shift in its position to roll the tropomyosin molecule away from the active sites on actin and thus allowing interaction between the energized myosin heads. Immediately after the active sites have been exposed, the energized myosin heads bind to them forming cross-bridges. Once cross-bridges have formed the energy that was stored in the resting state is released as the myosin heads rotate towards the M line. This movement is called the power stroke and is illustrated in Figure 2.4. During the power stoke the bound adenosine diphosphate (ADP) and phosphate molecules are released. When another ATP molecule binds to the myosin heads, the linkage between the myosin heads and the active site on the actin molecule is destroyed (Martini *et al*., 2014).

The active sites are now uncovered and able to form an additional cross-bridge. Myosin reactivation thus takes place when the free myosin head splits ATP into ADP and phosphate. The energy released is used to re-load the myosin heads, as the thick and thin filaments interact resulting in the shortening of the sarcomeres, pulling the ends of the muscle fibres closer together. Once the muscle has contracted, the entire skeletal muscle shortens and results in a pull, or tension, on the tendons at either end of the muscle belly (Martini *et al*., 2014).



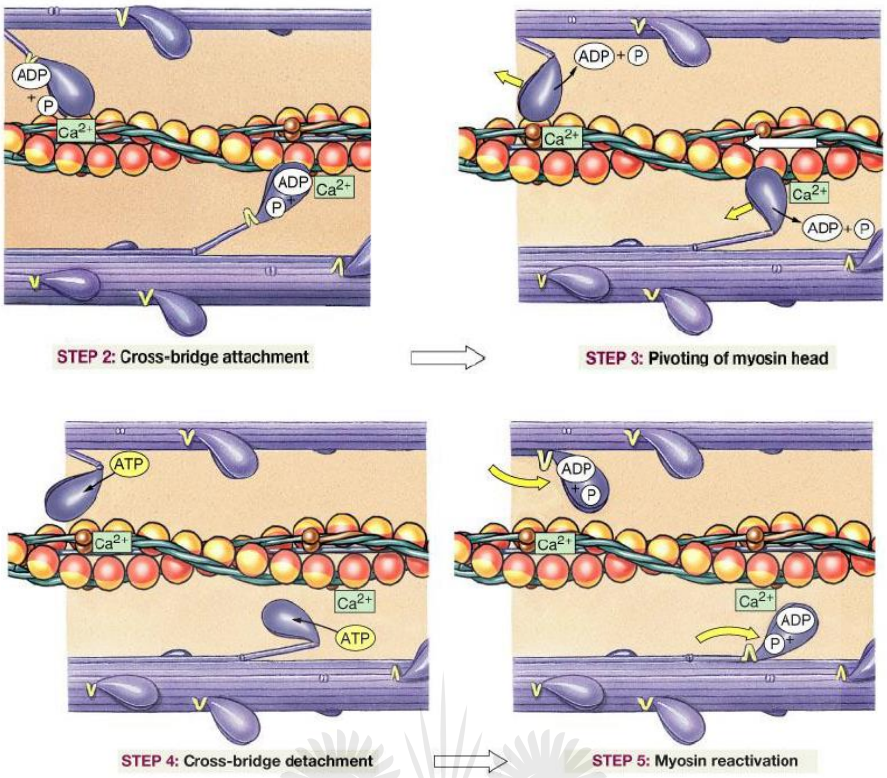


Figure 2.4: Physiology of a muscle contraction (Martini *et al*., 2014)

2.3 Anatomy of ankle

2.3.1 Introduction

A general understanding of the ankle anatomy was essential for this clinical study, as well as the anatomy of the peroneal musculature for a better understanding of the ankle biomechanics and how to determine the most effective treatment for ankle injuries. It was of importance to define what is considered normal verse abnormal anatomy concerning ankle injuries and ankle optimal functioning.

2.4.2 The ankle joint

The ankle joint or the talocrural joint is a uniaxial, modified hinge, synovial joint located between the superior part of the talus, the lateral malleolus of the fibula, and the medial malleolus of the tibia (Magee, 2007). The ankle joint contains three articulations namely the tibiotalar joint, subtalar joint and the distal tibiofibular joint syndesmosis (Hertel, 2002). The tibiotalar (mortise) joint is formed by three bony structures specifically the dome (trochlea) of the talus, medial and lateral malleoli. The malleolar mortise joint, formed by the distal ends of the tibia and fibula, is where the trochlea of the talus

articulate. The trochlea of the talus makes up the superior articular surface of the ankle joint and is rounded to fit perfectly between the medial and lateral malleoli. The medial surface of the lateral malleoli articulates with the lateral surface of the talus, while the medial malleolus articulates with the medial surface of the talus. The inferior surface of the tibia forms the roof of the malleolar mortise, transferring weight to the talus. The articulations between the talus and the calcaneus form the subtalar joint (Moore, Dalley & Agur, 2014). The third joint forms a syndesmosis between the tibia and the fibula (Hertel, 2002).

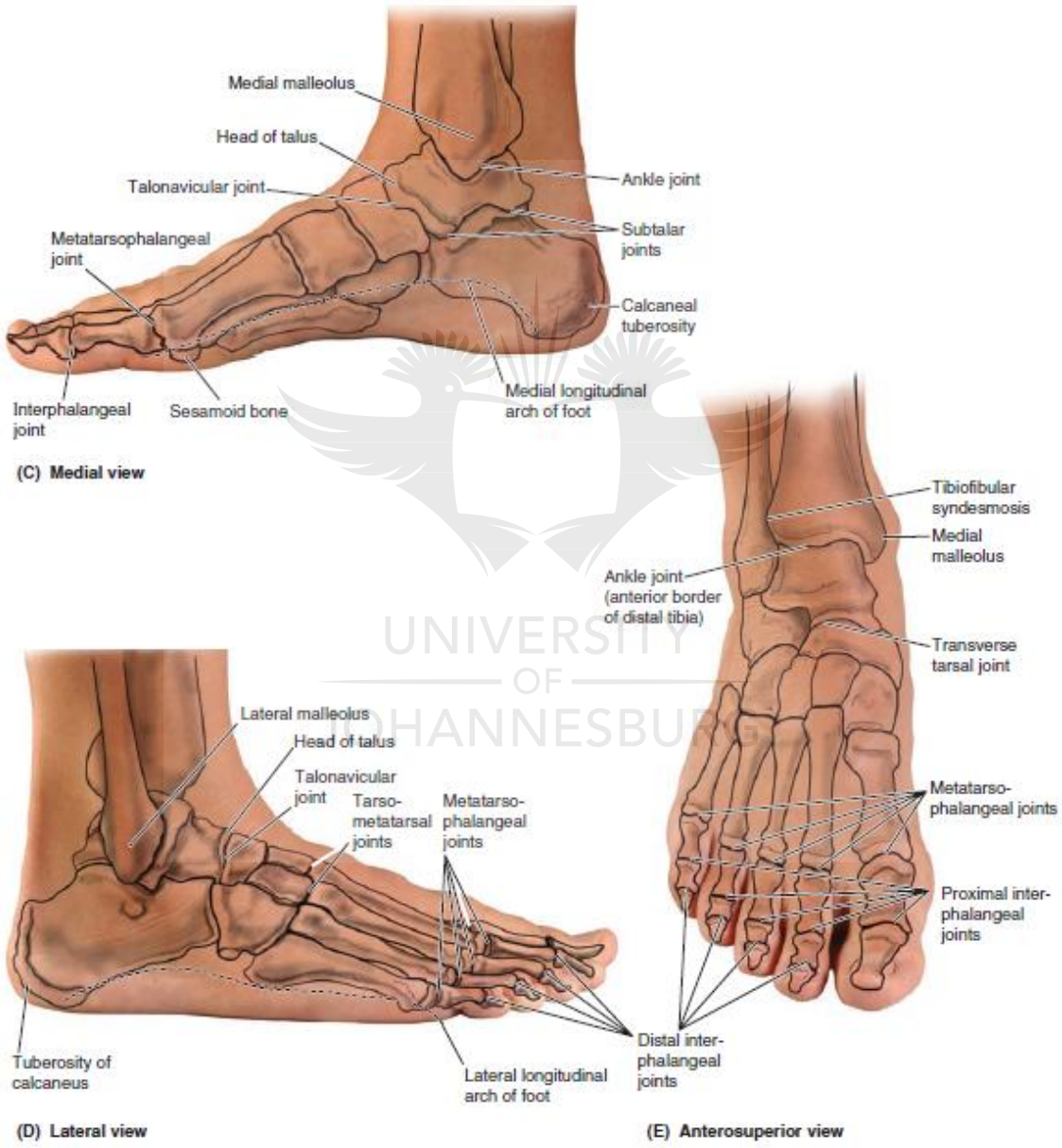


Figure 2.5: Anatomy of the right ankle joint (Moore *et al*., 2014)

2.4.3 Ligaments and capsule of the ankle joint

The capsule of the ankle joint is relatively weak and thin anteriorly and posteriorly, thus requires reinforcement. This reinforcement comes in the form of support from several lateral and medial ligaments which add strength to the capsule, assist in maintaining joint congruity and increase joint stability. The capsules fibrous layers are attached superiorly to the boarders of the articular surfaces of the tibia and the malleoli, and inferiorly to the talus (Moore *et al*., 2014).

The ligaments that make up the lateral collateral ligament complex of the ankle are the anterior talofibular, the calcaneofibular, and the posterior talofibular ligaments. The anterior talofibular ligament is a flat weak band that extends anteromedially from the lateral malleolus to the neck of the talus. The posterior talofibular ligament is a thick, strong band that attaches medially and slightly posteriorly from the malleolar fossa to the lateral tubercle of the talus running horizontally. The calcaneofibular ligament is a round cord that runs postero-inferiorly to originate from the tip of the lateral malleolus and inserts on the lateral surface of the calcaneus, this can be seen in figure 2.6 and 2.7 (Moore *et al*., 2014).

The ligaments that make up the medial collateral ligaments complex, commonly known as the deltoid ligament, are divided into a superficial and deep group of fibres. Three of these fibres are always present the tibiospring ligament, tibionavicular ligament, and deep posterior tibiotalar ligament, while the other three fibres are not always present, specifically the superficial posterior tibiotalar ligament, tibiocalcaneal ligament, and deep anterior tibiotalar ligament (Golanó, Vega, de Leeuw, Peter, Malagelada, Manzanares, Götzens & van Dijk, 2010). The interosseous ligament of the ankle is situated between the nearly congruent surfaces of the tibia and fibula, is deeply situated and could only be viewed upon rupture or in a cross section (Moore *et al*., 2014).

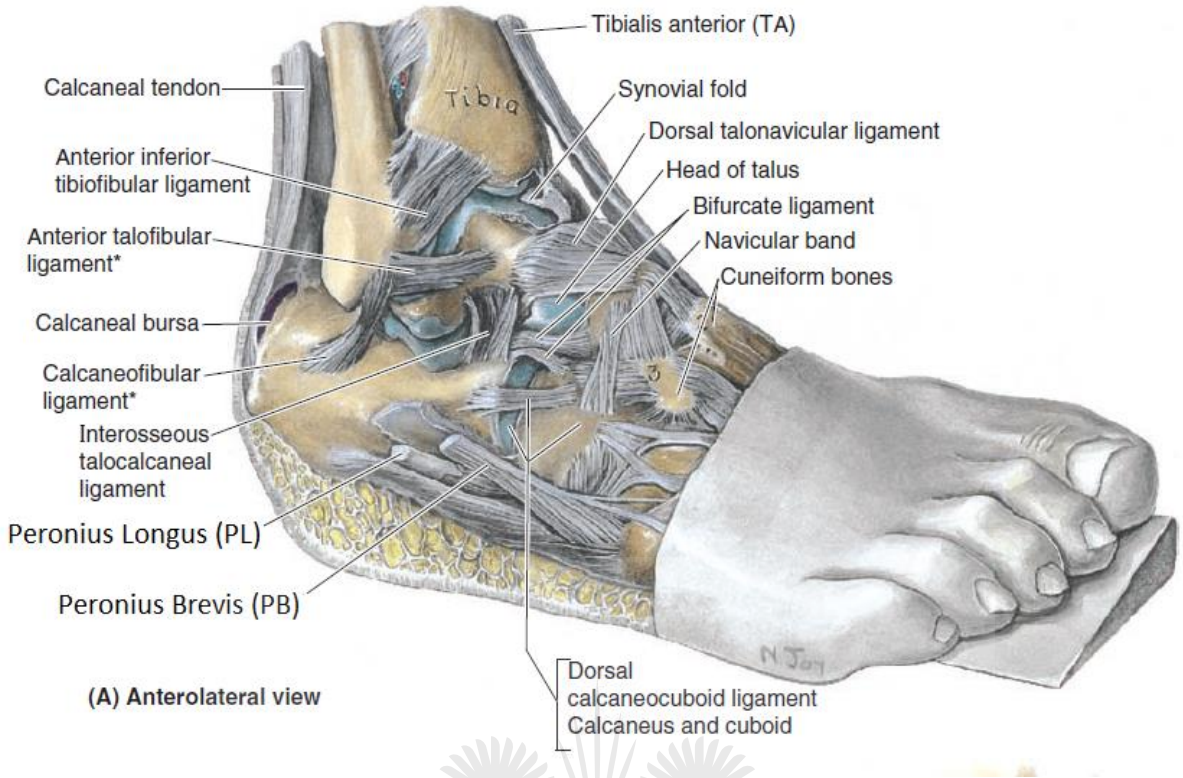


Figure 2.6: Ligaments of the right ankle joint modified from (Moore *et al*., 2014)

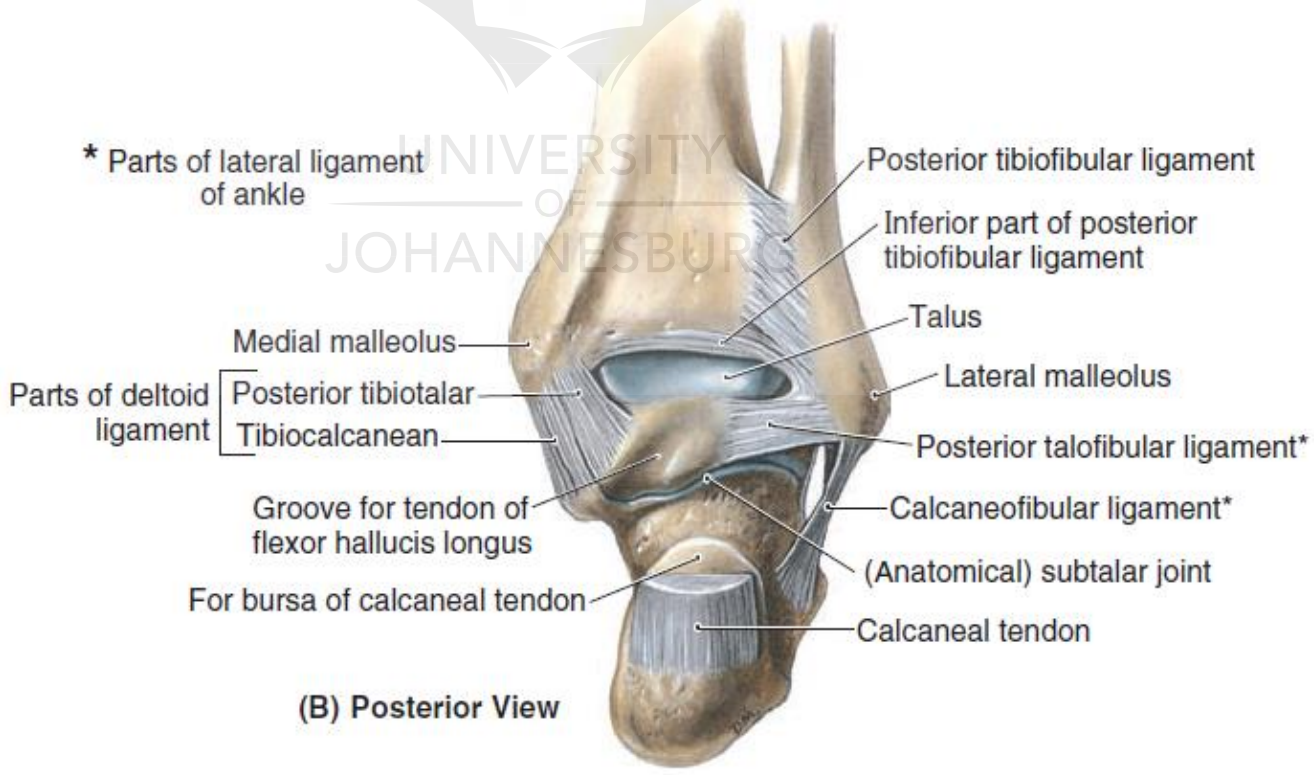


Figure 2.7: Ligaments of the right ankle joint (Moore *et al*., 2014)

2.4.4 Nerve supply to the ankle

The lower limb is innervated by five major nerves, namely the saphenous, tibial, sural, superficial peroneal, and deep peroneal nerve. These nerves are all involved in the sensory innervation of the ankle joint (Mentzel, Fleischmann, Bauer & Kinzl, 1999). The nerves that innervate the ankle joint are derived from the tibial nerve and the deep fibular nerve, a division of the common fibular nerve (Moore *et al*., 2014).

2.4.5 Joint kinematics of the ankle joint

The primary movements of the ankle joint are dorsiflexion and plantarflexion of the foot. These movements occur in a sagittal plane around a transverse axis passing through the talus. Dorsiflexion is made possible by the muscles in the anterior compartment of the leg, and is limited by the passive stretching of the triceps surae and tension in the medial and lateral ligaments. Plantarflexion is made possible by the muscles in the posterior compartment of the leg (Moore *et al*., 2014).

Abduction and adduction occur in the transverse plane while inversion and eversion occur in the frontal plane. Supination and pronation are three dimensional motions that are produced by a combination of these movements that occur across both the tibiotalar and subtalar joints. A combination of inversion, plantarflexion and adduction produce the movement of supination that results in the sole to face medially. During pronation a combination of eversion, dorsiflexion and abduction which causes the sole to face laterally (Brockett & Chapman, 2016).

2.5 Grading of Ankle Sprains

Ankle sprains could either be classified according to their position as a lateral ankle sprain, medial ankle sprain or a syndesmotic ankle sprain. Once determined according to anatomical location of the sprain, ankle sprains could be graded from one to three according the amount of fibre damage that occurs. This could be seen in figure 2.8, as it describes each grade of ankle sprain according to loss of function, stability, bruising, tenderness, and amount of swelling from mild to severe.

Grade I	Grade II	Grade III
• No loss of function • No ligamentous laxity with anterior drawer and talar tilt testing • Little or no bruising • No point tenderness • Decreased total ankle motion of 5 degrees or less • Swelling of 0.5 cm or less as measured by figure-of-eight testing	• Some loss of function • Positive anterior drawer test, negative talar tilt test • Bruising • Point tenderness • Decreased total ankle motion > 5 degrees but < 10 degrees • Swelling > 0.5 cm but < 2.0 cm	• Near total loss of function • Positive anterior drawer and talar tilt test • Bruising • Extreme point tenderness • Decreased total ankle motion > 10 degrees • Swelling >2.0 cm

Figure 2.8: Grading of ankle sprains (Wells, Allen, Deyle & Croy, 2019)

2.5.1 Ligamentous healing

There are three distinct phases that are involved in the process of ligament healing: phase one the inflammatory phase, phase two the reparative phase, and phase three the remodelling phase (Dubin, Dubin, Comeau, McClelland & Ferrel, 2011).

The acute inflammatory phase is the initial response to injury, occurring within the first twenty four to seventy two hours. Injury to the ligaments results in damage to the blood vessels within the ruptured ligaments and surrounding soft tissues. This in turn leads to a hematoma that fills the gap between the two retracted ligament ends. The capillaries within the surrounding area of the injured ligament increase in permeability, which would result in swelling and the infiltration of plasma proteins and leukocytes (white blood cells). The white blood cells undergo a process known as phagocytosis in which the cells engulf and remove the damaged cells and dead debris. During phagocytosis chemical mediators are released that encourage neovascularization. During the inflammatory phase nutrients and oxygen are readily available for the process of tissue healing to occur, seen in figure 2.9 (Dubin *et al*., 2011).

Phase two, the reparative phase of the healing process begins at three to five days post injury. Healthy cells replace the dead or damaged tissue by relaying connective tissue. At approximately five days post injury, the gap between the two retracted ligament ends is filled with granulation connective tissue, consisting of macrophages, new blood vessels, and fibroblasts. The fibroblasts produce proteoglycan and collagen, the subunits necessary for ligament repair. Collagen production intensifies; and by ten to fourteen days, disorganized collagen now connects the two ligament ends. The ligament may now be able to resist low-level tensile forces, mentioned in figure 2.9 (Dubin *et al*., 2011).

The remodelling phase of healing begins fifteen to twenty eight days post injury. The newly formed collagen fibres align themselves longitudinally, and cross-linkages form. By three weeks, as collagen maturation continues, the ligament may regain approximately 60 percent of its tensile strength. By three months, the ligament may regain its preinjury strength. The ligament healing process could be accelerated by immediately introducing an aggressive nonsurgical treatment protocol that initially reduces pain, swelling, inflammation and integrates early controlled motion. Studies have shown that early progressive rehabilitation has a positive end result in restoration of ligament tensile strength, decreases muscle atrophy, encourages lymphatic drainage, restores proprioception, and minimizes excessive arthrofibrosis or scarring. Reflected in figure 2.9 (Dubin *et al*., 2011).

	Inflammatory	**Proliferative**	**Remodeling**
Effect on blood	Increased blood flow	Formation of new blood vessels	New blood vessels mature
Symptoms	Swelling and pain increase	Swelling and pain subside	If tissue is strong, pain subsides
Physiology	Immune cells, called macrophages, remove damaged tissue	Immune cells, called fibroblasts, form new collagen	Increased density and diameter of collagen fibers occur if healing is not hindered
Length of time	Immediate response occurs for a week	Begins at day 2 or 3 after injury and continues for 6 weeks	Continues from day 42 until 18 months after injury

Figure 2.9: Stages of ligamentous healing (Nair, 2011)

2.6 Myofascial Trigger Points

The definition of a myofascial trigger point as defined by Simons, Travell and Simons (1999) is a hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. The spot is tender when pressed, and could give rise to characteristic referred pain, motor dysfunction and autonomic phenomena. Thus there is a new integrated hypothesis relating to the etiology of a myofascial trigger point which states that each myofascial trigger point encompasses a sensory, motor and an autonomic component (Dommerholt & Huijbregts, 2011). Myofascial trigger points more often than not create a primary dysfunction, and do not necessarily occur in conjunction with an underlying medical condition or tissue damage. Myofascial trigger points could be responsible for persistent peripheral nociceptive input independent of tissue damage, and could be associated with other conditions such as whiplash and osteoarthritis (Simons, Travell, Donnelly, Fernández-de-Las-Peňas, Finnegan & Freeman, 2019).

Myofascial trigger points can be classified as either active, latent, satellite, and primary or secondary. However, only active and latent trigger points have been considered in clinical practice and research. An active myofascial trigger point is symptomatic and could trigger local or referred pain, whereas a latent myofascial trigger point only produces pain when stimulated (Dommerholt *et al*., 2011).

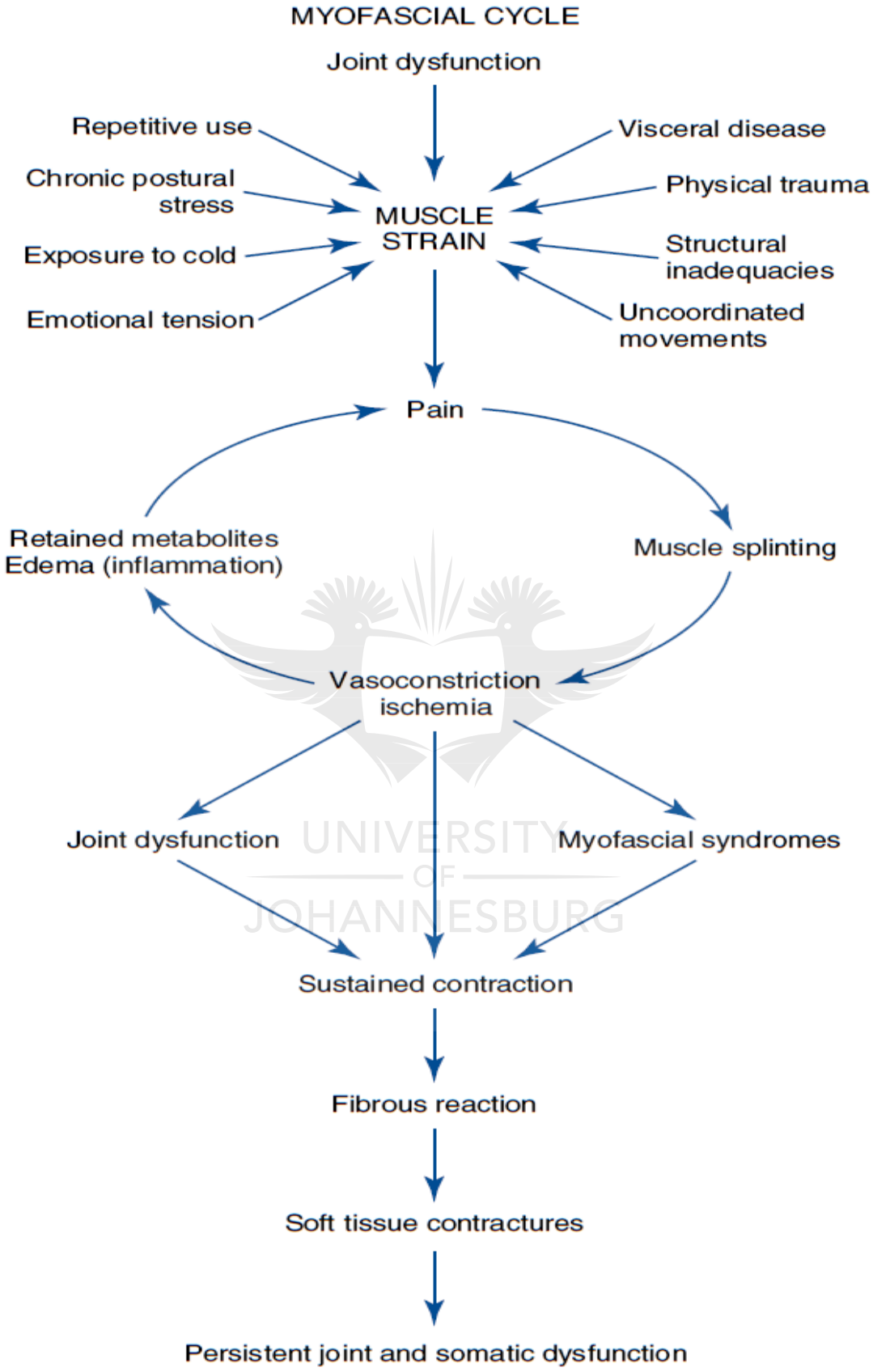


Figure 2.10: Cycle of myofascial trigger point causes (Bergman & Peterson, 2011)

2.6.1 Development of a myofascial trigger point

The exact cause of myofascial trigger points is still unknown, and numerous hypothetical models have been postulated to try and explain the formation of myofascial trigger points. The most accepted explanation for the development of myofascial trigger points remains the integrated hypothesis. However, alternative models have also been suggested such as the central modulation hypothesis, the neurogenic hypothesis, the neurophysiological hypothesis, or the radiculopathy hypothesis (Lluch, Nijs, De Kooning, Van Dyck, Vanderstraeten, Struyf & Roussel, 2015). The formation of myofascial trigger points have been linked to multiple mechanisms, including low-level muscle contractions, direct trauma, uneven intramuscular pressure distributions, unaccustomed eccentric contractions, maximal or submaximal concentric contractions and eccentric contractions in unconditioned muscles (Dommerholt *et al*., 2011).

2.6.2 The integrated theory

According to the integrated theory proposed by Simons, Travell and Simons (1999), myofascial trigger point formation is as a result of dysfunctional motor endplates. This in turn leads to abnormal depolarization of the post-junctional membrane of the motor endplate which results in a local hypoxic energy crisis. In a normal circumstance when a nerve impulse from an alpha-motor neuron reaches the motor terminal this causes an automatic response for voltage-gated sodium channels to open. This influx of sodium causes the depolarization of the terminal membrane and thus opens the volted-gated P-type calcium channels. Once the calcium enters the cell, a release from the nerve terminal into the synaptic cleft of acetylcholine-containing synaptic vesicles, ATP, 5HT, glutamate, and CGRP occurs. Inhibitory neuronal receptors, consisting of muscarinic, alpha 2 and beta-adrenoreceptors, nitric oxide receptors and purinergic P2Y receptors, prevent an excessive release of acetylcholine release. Acetylcholine (ACh) is also partially hydrolyzed by acetylcholine esterase (AChE) into acetate and choline which is later combined with co-enzyme A and synthesized into ACh again via acetyltransferase. The release of ACh is modulated by the concentration of acetylcholine esterase. Thus the inhibition of AChE would result in an accumulation of ACh in the synaptic cleft, which stimulate motor nerve endings and tonically activate nicotinic ACh receptpors (nAChRs). The inhibition of AChE may result in an increase of intracellular levels of calcium, which has been proposed to lead to the formation of taut bands, due to the fact that when calcium is not removed from the cytosol actin-myosin cross bridges remain intact. Therefore excessive amounts of ACh within the synaptic cleft would result in constant depolarization of the postsynaptic cells, trigger minimal endplate potentials, and

produce action potentials, which travel along the T-tubules towards the sarcoplasmic reticulum resulting in persistent contractions. These persistent contractions lead to compromised local blood vessels, reduced local oxygen supply, results in hypoxia, a lowered pH level and hypoperfusion, which in turn emphasizes the excessive release of ACh and contributes to muscle pain and dysfunction associated with the formation of myofascial trigger points (Simons *et al*., 2019).

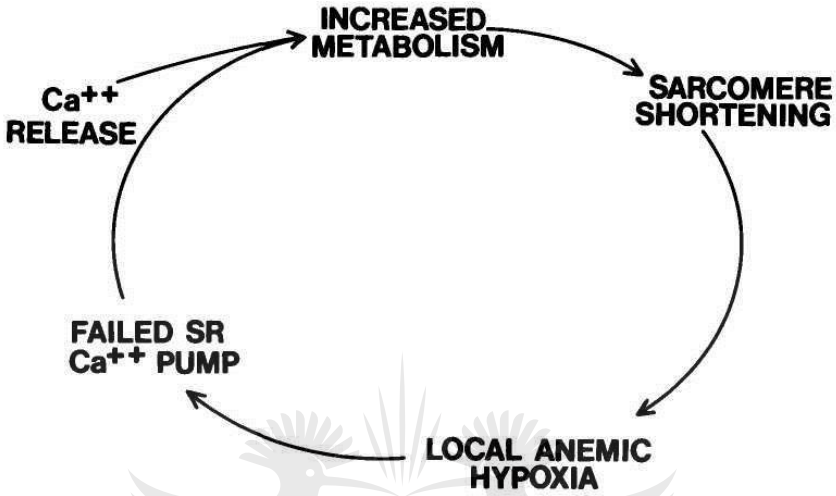


Figure 2.11: Schematic of a cycle of events that could maintain sarcomere shortening leading to trigger point formation (Simons *et al*., 2019)

2.6.3 Identification of active myofascial trigger points

Myofascial trigger points are identifiable by palpation, sonography and magnetic resonance imaging. However palpation was deemed reliable, as recent studies have proved that the taut band as by definition of myofascial trigger point, could be felt (Simons *et al*., 2019). See figure 2.12 for the location and referral patterns for the peroneal muscle trigger points.

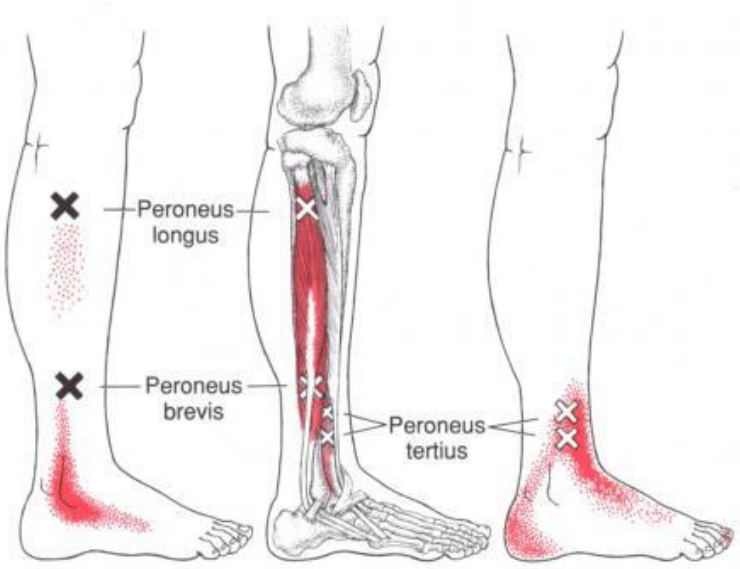


Figure 2.12: Trigger point location and referral patterns of peroneal muscles (Simons *et al*., 2019)

2.7 Formation of Peroneal Muscle Trigger Points in Traumatic Ankle Injuries

In most ankle injuries, re-injury occurs quite frequently with loss of stability and a decrease in overall functioning. This may be due to a condition called chronic ankle instability (CAI). There have been many suggestions about the major contributing factors to CIA and its characteristic disability, specifically the neuromuscular adaptations of the lower limbs after an acute ankle sprain. The neuromuscular alterations that seem to occur with CIA lead to reduced reflex excitability of the stabilizing muscles of the ankle. This in turn leads to a clinical impairment in gait, balance and pre-existing function. This also increases the risk for developing early onset osteoarthritis in the ankle. Although there are still gaps within the understanding of the neuromuscular dysfunctions origin, researchers have a theory that it was mechanisms within the central nervous system that modulate motor control in people with CAI (Pietrosimone *et al*., 2012).

Peroneal longus has been shown to have an essential role in resisting inversion ankle sprains. It has been suggested that instability in the ankle joint may be connected to the deficits that occur in the muscle spindles function when the ankle is exposed to a mechanical load. This was based on the Proprioceptive Theory, which states that during a lateral ankle sprain the foot is forced into an inverted position. The invertor muscle spindles have to therefore adapt to the newly shortened muscle length. The quick stretch of the invertor muscles, results in the contraction of the evertor muscles. This opposing contraction of the antagonistic muscle, results in rapid stretching of the invertor muscles from

its shortened position leaving the invertor muscles in a state of amplified neuromuscular hyperactivity with a facilitated spindle system (Collins, Masaracchio & Cleland, 2014).

This abnormal stress on the muscle leads to excessive release of intracellular calcium in certain muscle fibers. The sudden increase in calcium may lead to further shortening of the muscle spindle activity and an increase in metabolism, this in turn results in an impairment in the local circulatory supply. The decrease in local circulation causes impairment in the oxygen and nutrient supply to the area. Thus a brutal cycle begins causing an energy crisis to occur, and the formation of taut bands or a myofascial trigger point (Hong & Simons, 1998).

2.8 Myofascial Dry Needling

Dry needling is a soft tissue technique that makes use of acupuncture needles, and involves the insertion of a needle into an active trigger point. Dry needling is often used to treat myofascial pain. Myofascial pain is a condition of the muscle which produces a motor abnormality which could be described as a taut band (trigger point) within the muscle and a sensory abnormality which could cause pain within the muscle locally or could result in referred pain in a characteristic pattern specific to that muscle (Bachmann, 2005).

Dry needling is a type of soft tissue modality that is commonly used for the treatment of myofascial trigger points and is considered to be a minimally invasive technique that carries a low risk. Dry needling has been confirmed to be effective in numerous studies and 2 comprehensive systematic reviews. It has been noted that for the treatment of pain associated with myofascial trigger points, the deep method of dry needling has been shown to be more effective than the superficial method. Injection into a myofascial trigger point was a method established in 1942 by Dr Janet Travell and colleagues for the treatment of myofascial trigger points. In 1979, it was proposed that the effect of the injection were primarily cause by the mechanical stimulation of the myofascial trigger point with the needle by Karel Lewit. Since then, dry needling has been considered an effective way in treating myofascial trigger points and is widely used by practitioners and physical therapists (Kalichman & Vulfsons, 2010). Recent studies done on rodents have shown to be effective in reducing ACh and acetylcholine receptors (AChR) levels while increasing AChE levels, which have been linked to the cause of myofascial trigger point formation (Simons *et al*., 2019).

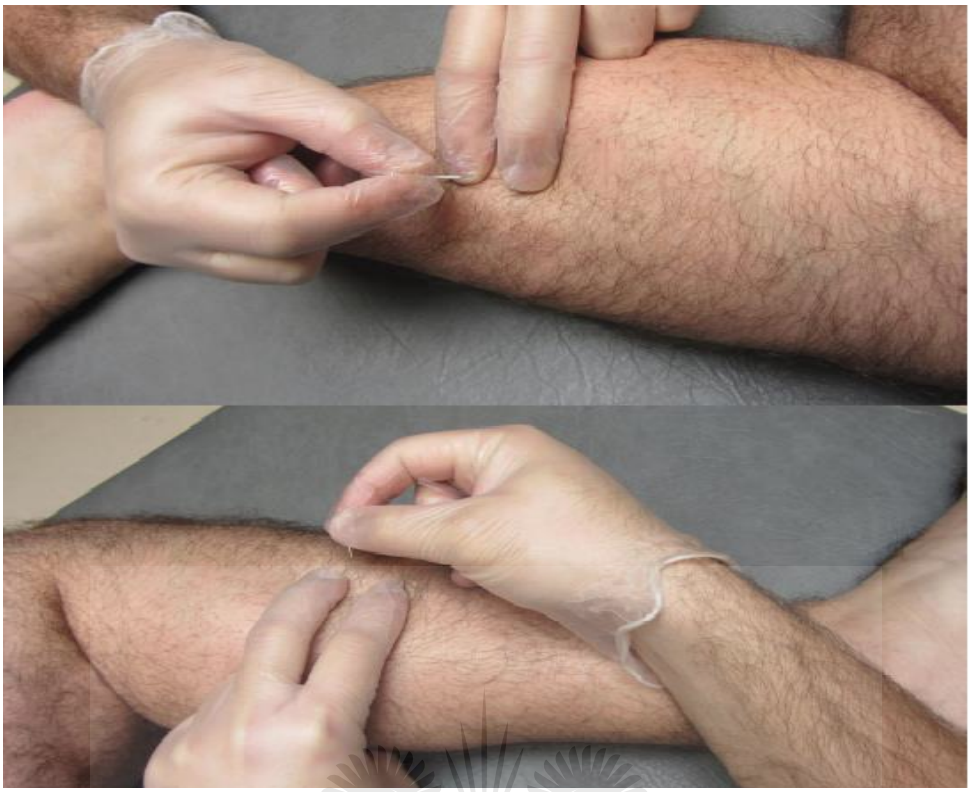


Figure 2.13: Dry needling of peroneal muscles (Salom-Moreno, Ayuso-Casado, Tamaral-Costa, Sánchez-Milá, Fernández-de-Las-Peñas & Alburquerque-Sendín, 2015)

2.8.1 Mechanism of myofascial dry needling

According to Simons, Travell and Simons (1999), the therapeutic effects of deep dry needling of a myofascial trigger points was mechanical disruption of the myofascial trigger point contraction knot. Myofascial trigger points have been linked to dysfunctional motor endplates, it is conceivable that deep dry needling damages or destroys the motor endplates and results in distal axon denervation when the needle is inserted in the myofascial trigger point. Evidence has shown that this could trigger specific changes in the endplates in the endplate cholinesterase and ACh receptor as part of the normal, muscle regeneration process. A needle inserted accurately into a myofascial trigger point may induce a localized stretch to the contractured cytoskeletal structures. This allows the sarcomeres that are involved to return back to their original resting length by reducing the degree of overlapping actin and myosin filaments. Rotation of the needle would allow increased localized stretch to the contractured structures that would enhance the effectiveness. The needle has been thought to add mechanical pressure which may electrically polarise muscle and connective tissue. This was found to be beneficial as the tissue remodelling process requires tissue to transform mechanical stress into electrical activity.

This is a physiological characteristic that collagen fibres possess which is known as intrinsic piezoelectricity (Dommerholt *et al*., 2011).

Dry needling has been proven to have an effect on pain reduction. Additionally, Ceccherelli (2002) proposed that muscle afferents could be of more significance than skin afferents and for the transmission of analgesic signals. Similarly, Itoh (2006) suggested that the occurrences of polymodal-type receptors (near the myofascial trigger point (MTrPs)) are responsive to thermal, mechanical, and chemical stimuli. Thus, needle penetration stimulates such receptors in the muscle to yield stronger effects on pain relief. Conversely, these same receptors have been suggested to be present in the dermis, and may account for the analgesic effects post stimulation of the dermis by penetration of the needles (Tekin, Akarsu, Durmuş, Çakar, Dinçer & Kıralp, 2013).

Insertion of a needle has also been shown to release vasoactive substance, such as CGRP and substance P which, activates Aδ- and C-fibers via the axon reflex, and leads to vasodilatation in small vessels and thus results in an increase in blood flow (Cagnie, Dewitte, Barbe, Timmermans, Delrue & Meeus, 2013).

A substantial reduction in pressure sensitivity supports the segmental antinociceptive effect of deep dry needling. Salom-Moreno (2015) found that a widespread change in pressure pain sensitivity post application of a needle in patients who had experienced a stroke, proposing a central effect (Mendigutia-Gómez, Martín-Hernández & Fernández-de-las-Peñas, 2016).

2.9 Extracorporeal Shockwave Therapy

Extracorporeal shockwave therapy (ESWT) is considered a safe non-invasive technique in which a device is used to deliver acoustic energy (shockwaves) through an epidermal area onto the affected surface (Leung, Malliaropoulos, Korakakis & Padhiar, 2018). Plantar fasciitis, calcific tendinopathies of the shoulder, non-union of long bone fractures and lateral epicondylitis of the elbow are common orthopaedic disorders that are treated by ESWT. Shockwave consists of rapid, short and distinct single fluctuations of acoustic energy from a positive to a negative phase. Within the target tissue the energy that is produced converges into 'the focal area or focal volume', whose size is dependent on the characteristics of the physical therapeutic stimulus, the angle at which it is applied and the generated pressure values. The direct effect of the shockwave is as a result of the consequent energy discharged close to the target tissue and the intensity of positive pressure. The phenomena of reflection,

absorption, transmission and refraction of the energy that is produced could be triggered by this event which is influenced by the tissues through which the wave front passes (Romeo, Lavanga, Pagani & Sansone, 2013).

Muscular shockwave therapy is now commonly referred to as “trigger point shockwave therapy” due to the fact that shockwaves have been proposed to be able to trigger the referred pain patterns that is normally seen in myofascial trigger points and treat the clinical symptoms that are associated with these trigger points (Ramon, Gleitz, Hernandez & Romero, 2015).

There are two different types of shockwaves namely radial and focused shockwaves that are known to be generated in different ways. Focused shockwaves are generated electrically, either within the applicator (electrohydraulic technique), or externally to it in the focal zone (electromagnetic or piezoelectric techniques), and then propagate to a designated focal point in order to treat it. Radial shockwaves are ballistic pressure waves generated at lower pressures over a longer time and propagate divergently within the tissue. The induced energy is produced in the tissue and converges into a focal or radial area, depending on the equipment used and the settings selected for intensity, angle and other parameters. The effect varies, depending on the tissue through which the wave passes and how it absorbs, reflects, refracts or transmits the energy, depending on the specific impedance (Ramon *et al*., 2015).

Figure 2.14: Image of Extracorporeal Shockwave machine (photo taken by researcher)

2.9.1 Mechanism of shockwave therapy

The exact mechanisms that allow tissues to recognize and convert the intensity, amplitude, frequency and duration of an acoustic signal into a biological reaction are not well known (Romeo *et al*., 2013). However, it has been proven that the effect of extracorporeal shock wave induces characteristic changes within the cells of living tissue, this is due to conversion of the mechanical signal into biochemical or molecular biologic signal (mechanotransduction). There are several hypotheses that have been debated regarding the principles of cellular and molecular biological effects. As stated by Zimmermann (2009) ESWT has been shown to improve local blood circulation in capillary blood vessels and decreases the tension and stiffness of muscles, as well as reduce pain by inducing a disruption of flow of excessive stimulation of nociceptors and stimulation of nerves (Jeon, Jung, Lee, Choi, Mun, Park, Seo & Jang, 2012).

A study that was done by Hausdorf (2008) goes on to show that ESWT could show a reduction in pain within the musculature through selective destruction of non-myelinated fibers. Hausdorf (2008) also stated that ESWT is effective in decreasing the level of substance P in the target tissue as well as reducing the synthesis of substance P in dorsal root ganglia. ESWT is known to increase the perfusion in the ischemic tissues through the reduction effect on inflammation, as well as stimulate neovascularization (Jeon *et al*., 2012). It has been proven that ESWT induces reversible structural changes in collagen conformation and orientation in tendon samples (Romeo *et al*., 2013). ESWT has been suggested to stimulate the release of proliferating factors and angiogenetic growth that promotes neovascularisation for the regeneration of tissue, as well as supress inflammatory mediators and directly reduce nociceptors by hyperstimulation analgesia (Leung *et al*., 2018).

Regarding, myofascial pain syndrome and the Energy Crisis Hypothesis that has been linked to the formation of trigger points, it has been proposed that shockwave therapy was able to break up Actin-Myosin links, as they are propagating perpendicularly to the sarcomere contractions (Ramon *et al*., 2015).

The understood mechanism of action for shockwave for the treatment of muscles could be linked to separation of the fixed actin-myosin links as a result of the input of mechanical energy perpendicular to the direction of muscle fibres, increase in local blood circulation through reactive hyperaemia and angioneogenesis, dilution of vasoneuroactive substances as a result of the reactive hyperaemia that is caused, modulation of pain through release of calcitonin gene-related peptide (CGRP) and substance

P, modulation of pain through the synthesis and release of nitric oxide, selective degeneration of C-fibres, modulation of pain that could be related to the pain gate control theory, and biological mechanotransduction (Gleitz & Hornig, 2012).

CHAPTER 3 - METHODOLOGY

3.1 Introduction

The details of the clinical trial are described and explained in this chapter. This chapter elaborates on the design of the study, how participants were recruited, the sample selection and size, randomization, and the treatment protocol. This chapter goes on to further describe the objective and subjective measurements that were used, the statistical analysis, and data evaluation used in this clinical trial.

3.1.1 Study design

This clinical trial was a quantitative, randomized study that was comparative in nature. The comparison between two different soft tissue modalities for the treatment of active peroneal trigger points in an ankle that had previously experienced an inversion ankle sprain, which was now chronic in presentation, was investigated. This clinical trial was carried out to determine which modality was comparatively more effective.

3.1.2 Participant recruitment

Participant recruitment was purely voluntary and individuals were recruited by means of an advertisement (Appendix A), which was placed around the chiropractic day clinic, the University of Johannesburg Doornfontein campus and also through word of mouth.

3.1.3 Sample selection and size

A selection of thirty participants, male or female between the ages of eighteen to thirty five years old, who had previously experienced an inversion ankle sprain, were recruited to partake in this study. Recruitment continued until there were fifteen participants in each group. A total of thirty participants took part in this clinical trial, as these were the requirements for this degree with the approval of STATKON (Appendix B).

3.1.4 Inclusion criteria

In order to have participated in this clinical trial, the participant had to comply with the following criteria:

- Participants had to be between the ages of 18-35 years. This age bracket eliminated the need for parental consent as well as reduced the risk of other conditions that could be the source of ankle pain such as osteoarthritis which is at a lower risk in adults under the age of 35 (Shane Anderson & Loeser, 2010).
- Males and females were included in this study as the study was not gender specific.
- History of a chronic inversion ankle sprain within the last seven years (Anandacoomarasamy & Barnsley, 2005) that had at least one of the diagnostic criteria mentioned (Appendix C)
- Presence of at least one active peroneal trigger point which was confirmed by measuring the trigger point tenderness with the pressure algometer (Sanz, Lobo, López, Morales, Martin & Corbalán, 2016) (Appendix D).

3.1.5 Exclusion criteria

Participants were excluded from this clinical trial if they presented with the following:

- Any participant who demonstrated any contra-indications to dry needling (Unverzagt, Berglund & Thomas, 2015) (Appendix E).
- Any participants who demonstrated any contra-indications to shockwave therapy (Shockwave Therapy, 2019) (Appendix F).
- Any participants with an ankle injury within the last three months.
- Any participants that have ankle pain caused by any other condition.
- Participants with no history of ankle trauma.
- Patients who are already receiving treatment or rehabilitation for the injured ankle.
- Patients who did not have active peroneal myofascial trigger points.
- Patients who are on any medications such as pain killers, anti-inflammatories or who have recently received any injections alike.

3.2 Randomization

This study used the stratification method of randomization according to age and gender, to reduce the risk of errors in estimation, this involved dividing the participants as they were recruited into two smaller groups of fifteen. As the participants were recruited, and all criteria were met for this study, the participants were randomly allocated to one of the subgroups. Females and males were divided equally between the two groups, to keep gender diversity in each group equal. The first male participant was allocated into group A, the next into group B. The same method was applied to all female participants, this process continued until all slots were filled. Age was also taken into consideration and the groups were split equally according to the age bracket (18 to 35 years) using the same process, to ensure each group had a similar amount of participants that were of a certain age. The participants were unaware of which treatment protocol corresponded with which group, therefore the participant was unaware of the type of treatment they were receiving until the group selection had been made. A total of thirty participants took part in this research, Group A received dry needling treatment, and group B received shockwave therapy.

3.3 Treatment Approach

3.3.1 First and follow-up visits

This clinical trial was conducted at the Chiropractic clinic at the University of Johannesburg, Doornfontein campus. The study was explained to the participant and the participant was required to read and sign the information letter (Appendix G), as well as a consent form (Appendix H). Once consent had been obtained the participant was subjected to screening where they were required to give a brief case history (Appendix I). A full physical examination (Appendix J) was performed on the participant, a lumbar regional (Appendix K), an ankle regional (Appendix L) and a SOAP (Appendix M) note was completed.

The patient was asked to rate their pain on a scale of zero to ten on the Numerical Pain Rating Scale (NPRS) (Appendix N). The passive range of motion of the previously sprained ankle was measured using the goniometer, three measurements were taken to obtain a mean value. Measuring the pain threshold (tenderness) of the most active trigger point in either peroneus longus or brevis muscle of the previously sprained ankle were taken using the hand held pressure algometer, three measurements were taken to obtain a mean value. The same active trigger point that was found on the first visit, was measured and treated throughout the visits.

Group A received dry needling to the most active myofascial trigger point of either the peroneus longus or brevis muscle of the previously sprained ankle. A needle was inserted into the active trigger point that was identified. The needle was left in situ for 10 minutes before it was removed (Appendix O).

Group B received shockwave therapy to the most active myofascial trigger point of either the peroneus longus or brevis muscle of the previously sprained ankle. Ultrasound gel was applied to the area of treatment. The shockwave machine was set to 1000 shocks, 12Hz and 1bar for tissue healing (Berta, Fazzari, Ficco, Enrica, Catalano & Frairia, 2009). The nozzle was in contact with the skin while a slight downward pressure was applied directly onto the trigger point identified. The treatment thus commenced as the shocks were delivered to the trigger point (Appendix P). It has been proposed that low to medium energy shockwave treatment induces much less cell destruction and more stimulation of cell proliferation (Berta *et al*., 2009).

3.3.2 Follow up visits

Each participant received six treatments involving either dry needling or shockwave therapy over the course of a three week period and a final seventh visit where only final measurements were taken. The initial visit was an hour long, whereas the follow up treatments took thirty minutes each, with the final seventh visit taking ten minutes. Treatment proceeded on days one through to six, over the three week period with two visits per week. During the first, fourth and seventh visit, measurements were taken and recorded.

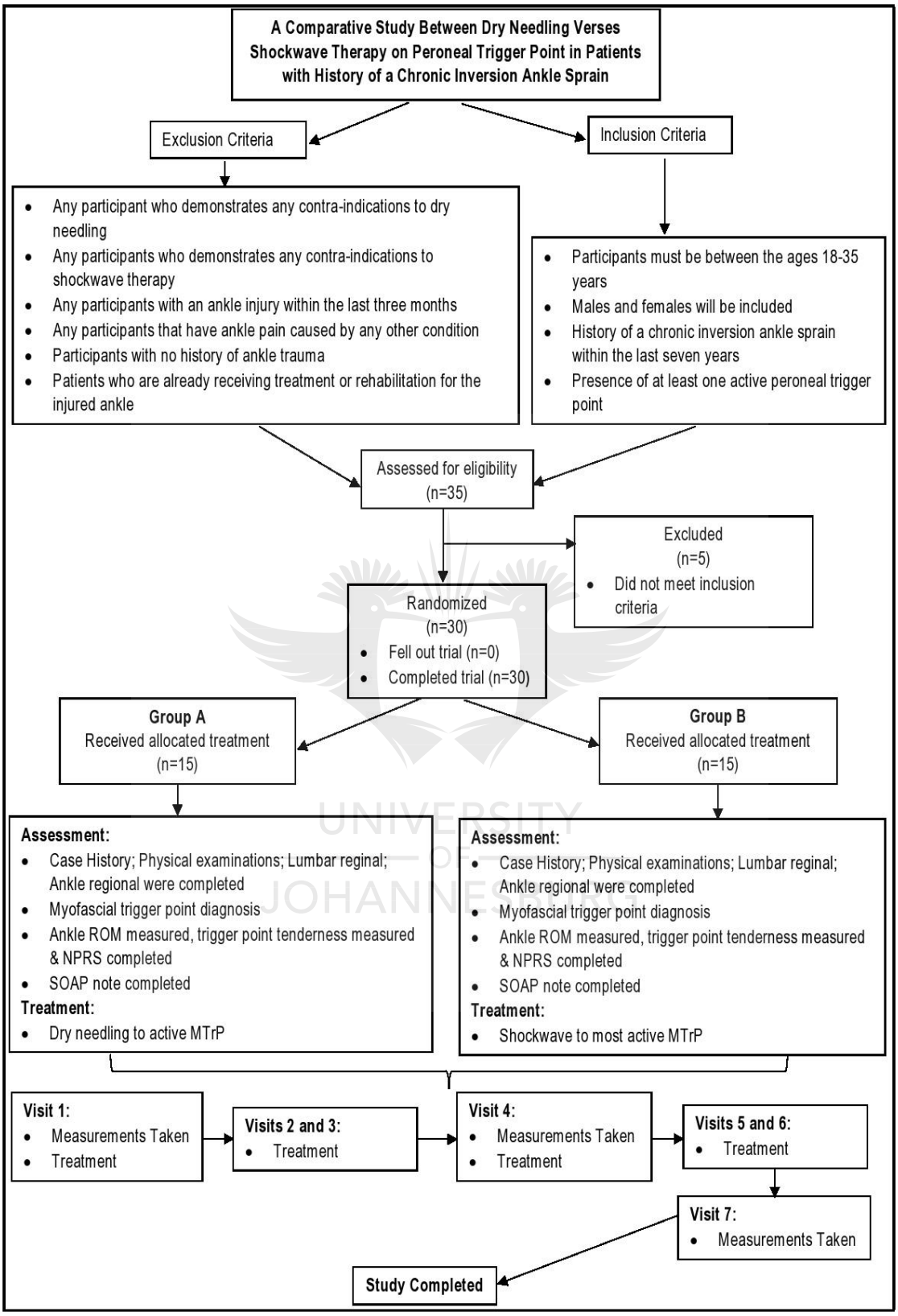


Figure 3.1: Flow diagram representing the method of the research process and participant flow

3.4 Objective Data

The objective measurements were taken using the pressure algometer to measure trigger point tenderness, as well as the goniometer to measure ankle range of motion.

3.4.1 Pressure algometer

A pressure algometer is a hand held device, which was used to measure the pain threshold of active trigger points in the peroneal muscles. The pressure algometer is a force gauge with a range of eleven Kg, and it consists of a rubber disc on the end, which is used for the quantification of deep muscle tenderness. It has been proven useful in the diagnosis of trigger points, fibrositis, myalgic spots, and activity of arthritis as well as assessment of pain sensitivity. The pressure algometer is used most often in clinical practice to measure the pressure threshold of a patient, which is considered the minimal pressure (force) at which pain could be induced (Fischer, 1987). If the researcher has familiarized themselves with the pressure algometer, the rate at which the force should be applied should be consistent in order for it to be considered reliable. When comparing the force plate readings with the algometer being tested, it concluded high reliability and validity values. This theory was supported by previous research done by Fischer (1987), Ylinen (2007), and Nussbaum and Downes (1998), demonstrating tolerable intraexaminer reliability of pressure rate application. Taking in to consideration these results, it could be said that, with practice, the use of this algometer was reliable and valid (Kinser, Sands & Stone, 2009).

Figure 3.2: Wagner pressure algometer used during this study (Potter & McCarthy, 2006)

3.4.2 Goniometer

This device was used to measure the ankle range of motion for this clinical trial. The goniometer has been the gold standard for measuring ankle joint dorsiflexion. The goniometer was used to measure the subtalar joints in the neutral position as well as passive range of motion of the ankle and subtalar joint in a clinical setting. The goniometer was deemed reliable in measuring the neutral and passive range of motion of the subtalar joint if the measurements are taken by the same practitioner over a short period of time (Elveru, Rothstein & Lamb, 1988). Intra-observer reliability was moderate to good within the same testing session, and between session reliability was maximum for inversion range of motion of the ankle (Menadue, Raymond, Kilbreath, Refshauge & Adams, 2006). There are many techniques that are available for measuring range of motion, however most practitioners consider the goniometer as the gold standard and its validity is currently widely accepted specifically when the measurements are taken by the same examiner within the same session on the same day (Rachkidi, Ghanem, Kalouche, El Hage, Dagher & Kharrat, 2009).

Figure 3.3: Goniometer used during the course of this trial to measure ankle range of motion (photo taken by researcher)

3.5 Subjective Data

The subjective data throughout this trial was collected using the NPRS.

3.5.1 Numerical Pain Rating Scale

A numerical scale from zero to ten was used to determine the level of peroneal muscle trigger point tenderness experienced by the participants. Participants were asked to rate their level of pain on the initial visit, the fourth visit and the seventh visit (Appendix N). The numerical value of zero is indicative of no pain and the numerical value of ten is indicative of severe pain. The NPRS was considered reliable and valid by Bolton and Wilkinson (Bolton & Wilkinson, 1998).

3.6 Data Analysis

All the subjective and objective data was collected throughout the study period by the researcher. The data was analysed by the researcher with the assistance of the statisticians in the STATKON department at the University of Johannesburg. The statistician used frequencies and descriptives to analyse the overall sample. Cross tabulation between groups and genders were completed using the Fisher's Exact test. The Sharpiro-Wilk test was used to determine normality of the distribution per group with less than fifty participants in a group.

The probability was calculated (p – value) to determine if the results showed a statistical significance or not. A p–value of more than or equal to 0.05 was indicative that there was no statistical significance that was noted. A p–value of less than 0.05 was indicative that there was a statistical significance that was noted.

Intergroup analysis (comparison between groups) tests were performed, and the data was deemed to be of an abnormal distribution therefore the Post-Hoc Mann-Whitney test was used to further analyse the data and determine where the difference occurred within the data.

Intragroup analysis (comparison within the groups over time) was performed using the non-parametric Friedman test, due to an abnormality within the data being noted during the analysis. A post-hoc test was carried out to determine specifically where the differences occurred over time, the Wilcoxon Signed Ranks test was used to determine this. Thus the Bonferroni adjustment was applied for the Post-Hoc

Wilcoxon signed-rank test. The new reported p-value according to the Wilcoxon signed-rank test is 0.025. Therefore a p-value ≤ 0.025 is suggestive of statistical significance. The Wilcoxon signed-ranks test indicates the comparison of the data between the different visits, comparing visits 1 and 4 and then visits 1 and 7. Results were collated by STATKON and interpreted by the researcher.

3.7 Ethical consideration

All participants that participated in this clinical trial were requested to read and sign the information letter (Appendix G) and consent form (Appendix H) specific to this study. The information and consent form outlined the names of the researcher, purpose of the study and benefits of partaking in the study, participant assessment and treatment procedure; any risks, benefits and discomforts pertaining to the treatments involved were also explained. The participant's safety was ensured (prevention of harm) at all times throughout the clinical trial. The information and consent form were explained to the participant, and the participants were made aware that their privacy will be maintained at all times throughout the study, as only the researcher, participant, supervisor and the clinician on duty would have access to the participants file and patient confidentiality would be ensured at all times. All information pertaining to the patient was kept in a file that was stored in a safe place in the clinic. The participant's information was kept confidential, as their information was converted into data and remained anonymous, as the data cannot be traced back to the individual. They were given a number to identify them, if the participant wishes to view their results. All data was kept on a password guarded computer, which only the researcher had access to. Throughout the study standard doctor-patient confidentiality was maintained. The participants were informed that their participation is on a voluntary basis and that they were free to withdraw from the study at any stage without any consequence. Should the participant have had any further questions, these would have been explained by the researcher; contact details were made available. Results of the study were made available on request of the participant.

Regarding this specific clinical trial, the following risks and discomforts may have occurred, related to this study that would have been applicable to dry needling, include mild peroneal pain or bruising of the area in which the needled was inserted, this is a normal response and will eased within one to two days (Yeganeh, Okhovatian, Naimi & Baghban, 2016). The risk of infection when using needles was very low, as all precautionary measures were taken to ensure that the risk of infection was minimized during the dry needling procedure. The needling protocol was strictly adhered to which includes the use of latex gloves and sterile needles, cleaning the area and hands with disinfectant which ensured that the

risk of contamination was avoided. All used needles were safely discarded in the sharps bin that was provided in each room in the clinic. With regards to shockwave, slight tenderness and or bruising over the area that was treated could be noted, which is considered to be a normal reaction, and would of resolved within the week. It was explained to the participant that if any of the risks or discomforts persisted longer than the above mentioned time period, the participant was to contact the researcher immediately, and the appropriate advise would have been given, or the appropriate action would have been taken to ensure that the participants safety was first priority at all times.

Possible benefits of this study included a mild decrease in tenderness of myofascial trigger point and a possible increase in ankle range of motion, as well as to aid in the prevention of further ankle trauma.

Permission was requested and granted from Dr Nonkwelo (A Comparative Study between Dry Needling verses Shockwave Therapy on Peroneal Trigger Point in Patients with History of a Chronic Inversion Ankle Sprain) to carry out my research on students on the Doornfontein campus at the University of Johannesburg (Appendix Q). This clinical trial involves the assignment of human participants or groups of humans to one or more health-related interventions to evaluate the effects, therefore was registered on Pan African Clinical Trial Registry (Appendix R).

This dissertation was submitted via anti-plagiarism software and the Turnitin report found it to be 19% (Appendix S). This research was approved by the Faculty of Health Science Higher Degrees (Appendix T) on the 27th of May 2019 HDC-01-16-2019 and the Research Ethics Committee (Appendix U) on the 27th of May 2019 REC-01-23-2019 at the University of Johannesburg.

CHAPTER 4 - RESULTS

4.1 Introduction

This chapter serves to present the data that was obtained throughout the clinical trial that was completed for this particular study. This study consisted of two groups with fifteen participants in each group. Group A was the group that received dry needling therapy, whilst group B received shockwave therapy. The data that is represented below was collected over seven visits at the University of Johannesburg Chiropractic Clinic. The subjective and objective data was taken on the first, fourth and seventh visits, while treatment continued throughout visits one through six. The subjective data is represented by the NPRS, while the objective data is represented by ankle range of motion which was measured with a goniometer and trigger point tenderness which was measured with the pain pressure algometer.

The data collected was statistically analysed in order to conclude which of the two different soft tissue approaches for the treatment of active peroneal trigger points were of more statistical significance, or which group yielded the best results. If there were any statistical differences noted within the data, further tests were performed.

Thirty participants was a relatively small sample size and therefore was not representative of the entire population. The significant value (or p-values) was given at a value of 0.05 (except where otherwise stated) and represented the level of significance within the results.

The data analysis included:

- Demographic data analysis
  - Age of participants
  - Gender of participants
  - Affected/treated leg
  - Peroneus longus or peroneus brevis trigger points
- Objective data collection
  - Pain pressure algometer
  - Goniometer
- Subjective data collection
  - NPRS

4.2 Analysis of Demographic Data

4.2.1 Age distribution

The age distribution for this study was tabulated below in table 4.1. Participants were required to be between the ages 18-35 years. This age bracket eliminated the need for parental consent as well as reduced the risk of other conditions that could have been the source of ankle pain such as osteoarthritis which was at a lower risk in adults under the age of 35 (Shane *et al*., 2010).

Table 4.1: Age distribution

Characteristics	Group A n=15	Group B n=15
Mean age	25.47	25.07
Age (Standard Deviation)	2.358	2.549
Age min-max	21 – 31	20 - 30
Age median (years)	25.00	25.00

A, Dry needling; B, Shockwave Therapy

The overall sample age ranged between 20 and 32 years old as represented by the thirty participants which took part in this study. The average age of the overall sample is 25.27 years with the median value being 25.00 years deviating 2.42 from the mean value. The p-value for age across the sample was **0.597**, which was regarded as statistically insignificant.

There were a total of 15 participants in group A. In group A the youngest participant that took part in this study was 21 years old, whilst the oldest participant was 31 years old. The mean age that represented group A was 25.47 (SD ± 2.358) years old. The median age was 25.00 years old, indicating that half the participants in group A were older than 25 years of age and half participants were younger than 25 years of age.

There were a total of 15 participants in group B. In group B the youngest participant that took part in this study was 20 years old, whilst the oldest participant was 32 years old. The mean age that represented group A was 25.07 (SD ± 2.549) years old. The median age was 25.00 years old, indicating that half the participants in group B were older than 25 years of age and half participants were younger than 25 years of age.

4.2.2 Gender distribution

The gender distribution for this study was tabulated below in table 4.2. Males and females were included in this study as the study was not gender specific, however females and males were consciously divided equally between the two groups, to keep gender diversity in each group equal.

Table 4.2: Gender distribution

Characteristics	Group A n=15	Group B n=15	Total (Percentage)
Males (Percentage)	4 (26.7%)	4 (26.7%)	8 (26.7%)
Females (Percentage)	11 (73.3%)	11 (73.3%)	22 (73.3%)
Total (Percentage)	15 (100%)	15 (100%)	30 (100%)

A, Dry needling; B, Shockwave Therapy

In table 4.2: above a total number of 30 participants which took part in this study could be seen, with a total of 15 participants that constitute each group.

In group A a total of 4 males and 11 females constitute the overall sample. This translates to an average of 26.7% of males and 73.3% of females that represent the overall sample size.

In group B a total of 4 males and 11 females constitute the overall sample. This translates to an average of 26.7% of males and 73.3% of females that represent the overall sample size.

Out of the 30 participants, 8 of them were male which made up 26.7% and 22 of them were female which made up 73.3% of the total sample size. The p-value for gender across the sample was **1.000**, which was regarded as statistically insignificant.

4.2.3 Side of treatment/injury

The prevalence of which side leg was treated or injured for this study was tabulated below in table 4.3. Each participant was required to have a history of a chronic inversion ankle sprain within the last seven years on at least one of their legs (Anandacoomarasamy *et al.*, 2005) (Appendix D).

Table 4.3: Side of treatment/injury

Characteristics	Group A n=15	Group B n=15	Total (Percentage)
Left (Percentage)	3 (20%)	2 (13.3%)	5 (16.7%)
Right (Percentage)	12 (80%)	13 (86.7)	25 (83.3%)
Total (Percentage)	15 (100%)	15 (100%)	30 (100%)

A, Dry needling; B, Shockwave Therapy

In table 4.3, above, it shows that out of the 15 participants in group A, 3 participants had experienced a chronic lateral ankle sprain on the left hand side which makes up 20% of the overall sample size. A total of 12 out of the 15 participants had experienced a chronic lateral ankle sprain on the right hand side, which makes up 80% of the overall sample size.

In table 4.3, above, it shows that out of the 15 participants in group B, 2 participants had experienced a chronic lateral ankle sprain on the left hand side, which makes up 13.3% of the overall sample size. A total of 13 out of the 15 participants had experienced a chronic lateral ankle sprain on the right hand side, which makes up 86.7% of the overall sample size.

This contributed out of the total 30 participants, a total of 5 participants had experienced a left hand side chronic ankle sprain, making up 16.7% of the overall sample size. A total of 25 participants had experienced a right hand side chronic ankle sprain, making up 83.3% of the overall sample size. The p-value for side of treatment across the sample was **0.624**, which was regarded as statistically insignificant.

4.2.4 Peroneus longus/brevis trigger point

The prevalence of the occurrence of either an active trigger point/s in peroneus longus or brevis for this study was tabulated below in table 4.4. The participants were required to have at least one active peroneal trigger point, in either longus or brevis, which was confirmed by measuring the trigger point tenderness with the pain pressure algometer (Sanz *et al.*, 2016) (Appendix E).

Table 4.4: Peroneus longus/brevis trigger points

Characteristics	Group A n=15	Group B n=15	Total (Percentage)
Peroneus Longus (Percentage)	9 (60%)	14 (93.3%)	23 (76.7%)
Peroneus Brevis (Percentage)	6 (40%)	1 (6.7%)	7 (23.3%)
Total (Percentage)	15 (100%)	15 (100%)	30 (100%)

A, Dry needling; B, Shockwave Therapy

In the above table 4.4 it has been established that out of the 15 participants in group A, 9 participants had an active peroneus longus trigger point, which makes up 60% of the overall sample size. A total of 6 out of the 15 participants had an active peroneus brevis trigger point, which makes up 40% of the overall sample size.

In the above table 4.4 it has been established that out of the 15 participants in group B, 14 participants had an active peroneus longus trigger point, which makes up 93.3% of the overall sample size. A total of 1 out of the 15 participants had an active peroneus brevis trigger point, which makes up 6.7% of the overall sample size.

This contributed out of the total 30 participants, a total of 23 participants that had an active peroneus longus trigger point, making up 76.7% of the overall sample size. A total of 7 participants had an active peroneus brevis trigger point, making up 23.3% of the overall sample size. The p-value for proximal or distal trigger point across the sample was **0.031**, which was regarded as statistically significant.

4.2.5 Test for normality

The Shapiro-Wilk test was used to determine if the random sample was of a normal distribution. The Shapiro-Wilk test was the test of choice due to the sample size being small (n>50). The p-value stands for the probability; the probability was calculated to determine if the results were statistically significant or not. A p-value of more than or equal to 0.05 was indicative of a normal distribution, denoting that there was no statistical significance that could be noted, suggesting that there was no difference between groups or over time. A p-value of less than 0.05 is indicative of an abnormal distribution,

denoting that there was a statistical significance that could be noted, suggesting that there was a difference between the groups or over time.

4.3 Results from Statistical Data

Throughout this clinical trial there was no normal distribution that was detected for the subjective and objective data that was collected. Therefore, the non-parametric tests were employed for both intragroup and intergroup analysis. The non-parametric tests were also used due to the fact that the sample size was relatively small and because there were some outlying values within the data. For the comparison within the two groups (intragroup), the non-parametric test that was used was the Friedman test. The non-parametric tests, Mann-Whitney test was used for comparison between the two groups (intergroup). The non-parametric, Wilcoxon Signed Rank test was used for Post-hoc testing to determine the difference over time and where the differences occurred. This specific Post-hoc test uses the Bonferroni procedure, which sets a significance cut off. This was due to the fact that performing multiple independent or dependent statistical tests at the same time could result in the probability of a significant result increases with each test done.

For this clinical trial a Bonferroni adjustment was applied to the p-value for the Post-Hoc tests. This involved dividing the p-value of 0.025 by the number of tests involved. The now reviewed p-value, to be used when trying to determine the statistical significance was 0.0167. Therefore, a p-value of $p \leq 0.0167$ showed statistical significance for the smallest p-value, $p \leq 0.025$ for the second smallest p-value and $p \leq 0.05$ for the highest value (Pallant, 2007).

4.4 Subjective Data Analysis

4.4.1 Numerical pain rating scale

The Shapiro-Wilk test was conducted as the preliminary test to determine if the data was of a normal distribution.

Table 4.5: Group means and standard deviation - of visit 1, 4 and visit 7; - for differences between groups; - for differences within groups regarding NPRS

	Visit 1 Mean	Visit 4 Mean	Visit 7 Mean	Percentage change between 1-7	Difference within groups	Statistical significance
NPRS						
Group A n=15	4.20 (SD ±1.320)	1.60 (SD ±1.056)	0.80 (SD ±0.882)	80.95% Increased	p = 0.000	Significant
Group B n=15	4.27 (SD ±1.100)	2.13 (SD ±1.302)	1.13 (SD ±0.915)	73.54% Increased	p = 0.000	Significant
Difference between groups	p = 0.764	p = 0.212	p = 0.268			
Statistical Significance	Not significant	Not significant	Not Significant			

A, Dry needling; *B*, Shockwave; *NPRS*, NPRS (0 → 10).

With regards to group A (dry needling) upon visit 1, a mean value of 4.2 (SD ±1.320) was noted, which thus decreased to 1.6 (SD ±1.056) upon visit 4 and further decreased to 0.8 (SD ±0.882) upon visit 7. Thus an 80.95% improvement in the levels of pain in which the participant was experiencing from the chronic inversion sprain could be deduced.

With regards to group B (shockwave) upon visit 1, a mean value of 4.27 (SD ±1.100) was noted, which thus decreased to 2.13 (SD ±1.302) upon visit 4 and further decreased to 1.13 (SD ± 0.915) upon visit 7. Thus a 73.54% improvement in the levels of pain in which the participant was experiencing from the chronic inversion sprain could be deduced.

However, a decrease in the levels of pain that the participant was experiencing from the chronic inversion sprain could be seen in the groups bilaterally. Although there was a 0.07 difference between the two groups starting points noted. Group A yielded a better result clinically with the greatest decrease in the overall levels of pain that the participant was experiencing from the chronic inversion sprain, from the 1st visit to the 7th thus a difference of 3.4 was noted.

The Man-Whitney and Friedman tests were conducted as the non-parametric test as the data was not normally distributed. Due to the small sample size and outlying parameters, there was only a slight difference noted between the two test groups which indicated no statistical significant.

Intragroup analysis

The Friedman and Wilcoxon signed-rank test was used to analyse the data, which yielded the following results as shown in table 4.5.

There was a statistically significant difference noted over time in group A with a p–value **of 0.00 ($p \leq 0.05$)**. Subsequently, there was a statistically significant difference that was noted over time for group B with a p-value of **0.00 ($p \leq 0.05$)**.

As the above statement indicated during the Friedman's tests, there were statistically significant differences reported within the data. Thus the Bonferroni adjustment was applied for the Post-Hoc Wilcoxon signed-rank test. The new reported p-value according to the Wilcoxon signed-rank test was 0.025. Therefore a p-value ≤ 0.025 was suggestive of statistical significance. The Wilcoxon signed-ranks test indicated the comparison of the data between the different visits, comparing visits 1 and 4, and then visits 1 and 7.

Table 4.6: Wilcoxon signed-rank test for NPRS (p-value)

Comparison between visits	Group A n=15	Group B n=15
1-4	0.001	0.001
1-7	0.001	0.001

A, Dry needling; B, Shockwave Therapy

Group A analysis:

As reported in table 4.6 above there was a statistically significant difference that was noted between the 1st and 4th visits with a p-value of **0.001 ($p \leq 0.025$)** for group A. As for the comparison between the 1st and 7th visits, there was a statistically significant difference that was reported with a p-value **of 0.001 ($p \leq 0.025$)** for group A.

Group B analysis:

There was a statistically significant difference that was noted between the 1st and 4th visits with a p-value of **0.001 (p ≤ 0.025)** for group B. As for the comparison between the 1st and 7th visits, there was a statistically significant difference that was reported with a p-value of **0.001 (p ≤ 0.025)** for group B.

Intergroup analysis

The intergroup analysis was conducted using the non-parametric Mann-Whitney U test to determine if there was a difference in measurements between the groups. These results are reported in table 4.5 above.

The Mann-Whitney U test analysed the data from the NPRS between both groups for visit 1, 4 and 7. The difference between the two groups at visit 1 was **0.764 (p > 0.05)** and was not deemed to be statistically significant. The difference between the two groups at visit 4 was **0.212 (p > 0.05)** and was therefore not deemed to be statistically significant. Consequently, the difference between the two groups at visit 7 was **0.268 (p > 0.05)** and thus was not deemed to be statistically significant.

Subsequently, there were only two comparable groups therefore, if a statistically significant difference was noted, no Post-Hoc test was required for further analysis as the difference was noted between the two groups.

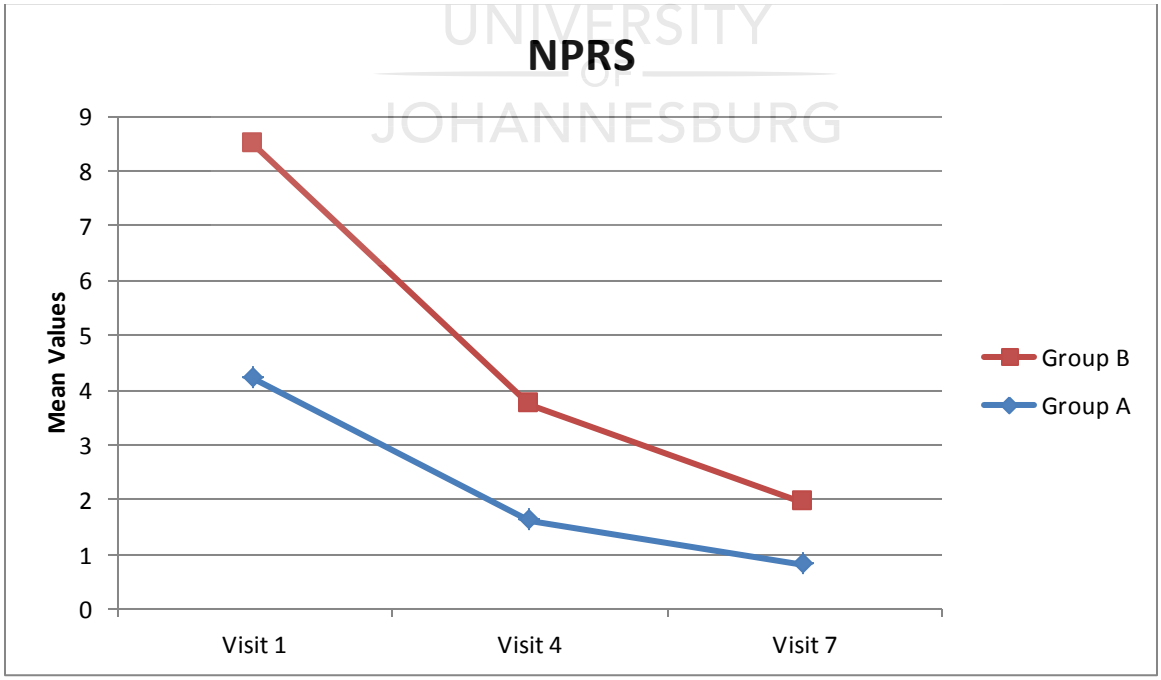


Figure 4.1: Line graph showing the mean differences for the NPRS readings (over visits 1, 4 and 7) for groups A and B

In figure 4.1 above one could depict that there was a decrease in the levels of pain in which the participant experienced from the chronic inversion sprain from visit 1 to 7 in both groups. The above line graph compares the mean values of the NPRS from visit 1 (first measurements were taken) to visit 4 (second measurement were taken) and visit 7, where the final measurements were taken.

The above line graph (figure 4.1) compares the mean values of the NPRS from visit 1 (first measurements were taken) to visit 4 (second measurement were taken), and visit 7 where the final measurements were taken.

4.5 Objective Data Analysis

4.5.1 Pressure algometer

The pressure algometer results were analysed using the Shapiro-Wilk test to determine normality of the data distribution. Due to the abnormally distributed nature of the data a non-parametric test was thus further conducted. The Mann-Whitney U (intergroup) test was preformed comparing the differences between the two independent groups.

The non-parametric Friedman (intragroup) test was conducted to compare each group independently. This test was used to detect any differences within the groups, comparing treatments across multiple test attempts. This test was done only if the data distribution was not normally distributed, as was the case with the data that was collected throughout this clinical trial.

Table 4.7: Group means and standard deviation - of visit 1, 4 and visit 7; - for pain pressure differences between groups; - for differences within groups regarding algometer readings

	Mean value visit 1	Mean value visit 4	Mean value visit 7	Percentage change between 1-7	Difference within groups	Statistical significance
PPA (kg/cm²)						
Group A n=15	3.42 (SD ±0.749)	3.91 (SD ±0.518)	4.53 (SD ±1.009)	32.46% Increased	p = 0.005	Significant
Group B n=15	3.41 (SD ±0.658)	4.04 (SD ±0.673)	4.79 (SD ±0.752)	40.47% Increased	p = 0.000	Significant
Difference between groups	P = 0.771	p = 0.329	p = 0.318			
Statistical Significance	Not significant	Not significant	Not significant			

A, Dry needling; B, Shockwave; Pain Pressure Algometer (kg/cm²).

With regards to group A (dry needling) upon visit 1, a mean value of 3.42 kg/cm² (SD ±0.749) was noted, which thus increased to 3.91 kg/cm² (SD ±0.518) upon visit 4, and further increased to 4.53 kg/cm² (SD ±1.009) upon visit 7. Thus a 32.46% improvement in trigger point tenderness could be deduced.

With regards to group B (shockwave) upon visit 1, a mean value of 3.41 kg/cm² (SD ± 0.658) was noted, which thus increased to 4.04 kg/cm² (SD ± 0.673) upon visit 4, and further increased to 4.79 kg/cm² (SD ± 0.752) upon visit 7. Thus a 40.47% improvement in trigger point tenderness could be deduced.

However there was a decrease in trigger point tenderness that could be seen in both groups, with a 0.01 difference between the two groups starting points. Group B yielded a better result clinically with the greatest decrease in overall trigger point tenderness. From the 1st visit to the 7th group B had a difference of a 1.38 increase in the mean value that was noted.

Intragroup analysis

The Friedman and Wilcoxon signed-rank test was used to analyse the data, which yielded the following results as shown in table 4.7.

There was a statistical significance noted over time in group A with a p–value of **0.005 (p ≤ 0.05)**. Additionally, there was a statistical significance that was noted over time for group B with a p-value of **0.000 (p ≤ 0.05)**.

As the above statement indicated during the Friedman's tests, there were statistically significant differences reported within the data. Thus the Bonferroni adjustment was applied for the Post-Hoc Wilcoxon signed-rank test. The new reported p-value according to the Wilcoxon signed-rank test was 0.025. Therefore a p-value ≤ 0.025 is suggestive of statistical significance. The Wilcoxon signed-ranks test indicates the comparison of the data between the different visits, comparing visits 1 and 4, and then visits 1 and 7.

Table 4.8: Wilcoxon signed-rank test for ankle pressure algometer (p-value)

Comparison between visits	Group A n=15	Group B n=15
1-4	**0.021**	**0.010**
1-7	**0.005**	**0.001**

A, Dry needling; B, Shockwave Therapy

Group A analysis:

As reported in table 4.8 above there was a statistically significant difference that was noted between the 1st and 4th visits with a p-value of **0.021 (p ≤ 0.025)** for group A. As for the comparison between the 1st and 7th visits, there was a statistically significant difference that was reported with a p-value of **0.005 (p ≤ 0.025)** for group A.

Group B analysis:

There was a statistically significant difference that was noted between the 1st and 4th visits with a p-value of **0.010 (p ≤ 0.025)** for group B. As for the comparison between the 1st and 7th visits, there was a statistically significant difference that was reported with a p-value of **0.001 (p ≤ 0.025)** for group B.

Intergroup analysis

The inter-group analysis was conducted using the non-parametric Mann-Whitney U test to determine if there was a difference in measurements between the groups. These results are reported in table 4.7 above.

The Mann-Whitney U test analysed the results from the pressure algometer, between both groups for visits 1, 4 and 7. The difference between the two groups at visit 1 was **0.771 (p > 0.05)** and was not deemed to be statistically significant. The difference between the two groups at visit 4 was **0.329 (p > 0.05)** and was therefore not deemed to be statistically significant. Subsequently, the difference between the two groups at visit 7 was **0.318 (p > 0.05)** and thus was not deemed to be statistically significant.

Subsequently, there were only two comparable groups. Therefore, if a statistically significant difference was noted, no Post-Hoc test was required for further analysis as the difference was noted between the two groups.

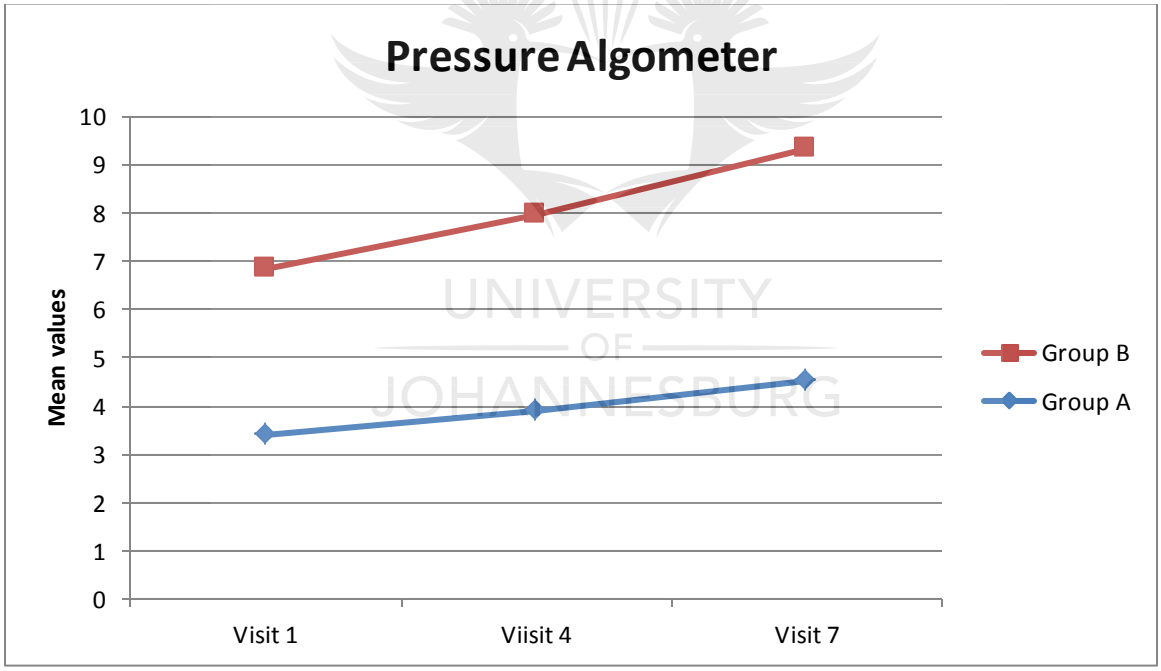


Figure 4.2: Line graph showing the mean differences for the pressure algometer readings (over visits 1, 4 and 7) for groups A and B

In figure 4.2 above one could depict that there was an increase in pressure algometer readings between group A and B, thus a decrease in trigger point tenderness perceived from visits 1 to 7 in both groups could be noted. The above line graph compares the mean values of the pressure algometer

from visit 1 (first measurements were taken) to visit 4 (second measurement were taken) and visit 7, where the final measurements were taken.

The above line graph (figure 4.2) compares the mean values of the pressure algometer measurements from visit 1 (first measurements were taken) to visit 4 (second measurement were taken), and visit 7 where the final measurements were taken.

4.5.2 Goniometer

A goniometer was used to measure the ankle range of motion of the affected side. These measurements included dorsiflexion, plantarflexion, eversion and inversion. The unit of measurement for the goniometer is degrees (°), therefore an increase in the degrees thus indicates an increase in range of motion. An increase in the measurements between visits is indicative of an improvement in ankle range of motion. This was significant for this clinical trial as an increase of ankle range of motion may indicate a decrease in peroneal trigger points. However a decrease in the measurements between the treatments was indicative of a decrease in ankle range of motion, thus a worsening or an increase of peroneal trigger points may have occurred during the course of treatment.

The goniometer results were analysed using the Shapiro-Wilk test to determine normality of the data distribution. Due to the abnormally distributed nature of the data a non-parametric test was thus further conducted. The Mann-Whitney U (intergroup) test was preformed comparing the differences between the two independent groups.

The non-parametric Friedman (intragroup) test was conducted to compare each group independently. This test was used to detect any differences within the groups, comparing treatments across multiple visits. This test was done only if the data distribution was not normally distributed, as was the case with the data that was collected throughout this clinical trial.

a) Dorsiflexion of the ankle joint

The Shapiro-Wilk test was conducted as the preliminary test to determine if the data was of a normal distribution.

Table 4.9: Group means and standard deviation - of visit 1, 4 and visit 7; - for differences between groups; - for differences within groups regarding goniometer readings (dorsiflexion)

	Mean value visit 1	Mean value visit 4	Mean value visit 7	Percentage change between 1-7	Difference within groups	Statistical significance
Dorsiflexion						
Group A n=15	9.53 (SD ±8.236)	7.53 (SD ±5.072)	10.40 (SD ±6.533)	9.13% Increased	p = 0.049	Significant
Group B n=15	7.40 (SD ±6.577)	7.40 (SD ±6.254)	4.73 (SD ±5.216)	36.08% Decreased	p = 0.168	Not significant
Difference between groups	P = 0.588	p = 0.818	p = 0.012			
Statistical Significance	Not significant	Not significant	Significant			

A, Dry needling; B, Shockwave; Range of motion Goniometer (°)

With regards to group A (dry needling) upon visit 1, a mean value of 9.53° (SD± 8.236) was noted, which thus decreased to 7.53° (SD± 5.027) upon visit 4 and further increased to 10.40° (SD± 6.533) upon visit 7. Thus a 9.13% improvement in ankle dorsiflexion could be deduced between visits 1 and 7.

With regards to group B (shockwave) upon visit 1, a mean value of 7.40° (SD± 6.577) was noted, which thus remained the same with a mean value of 7.40° (SD± 6.254) upon visit 4 and then further decreased to a mean value of 4.73° (SD± 5.216) upon visit 7. Thus 36.08% deterioration in ankle dorsiflexion could be deduced between visits 1 and 7.

However there was an increase in ankle dorsiflexion throughout the treatment course that could be seen for group A with a 2.13° difference between the two groups' starting points. Group B showed that there was a decrease in ankle dorsiflexion throughout the treatment course, thus showing that group A yielded better results with an overall increase in ankle dorsiflexion throughout the treatment course. From the 1st visit to the 7th group A had a difference of a 0.87° increase in the mean value that was noted, and thus substantiates the above statement.

Intragroup analysis

The Friedman and Wilcoxon signed-rank test was used to analyse the data, which yielded the following results as shown in table 4.9.

There was a statistical significance noted over time in group A with a p–value of **0.049 (p ≤ 0.05)**. However, there was no statistical significance was noted over time for group B with a p-value of **0.168 (p > 0.05)**.

As the above statement indicated that during the Friedman's tests, there were statistically significant differences reported within the data. Thus the Bonferroni adjustment was applied for the Post-Hoc Wilcoxon signed-rank test. The new reported p-value according to the Wilcoxon signed-rank test was 0.025. Therefore a p-value ≤ 0.025 was suggestive of statistical significance. The Wilcoxon signed-ranks test indicates the comparison of the data between the different visits, comparing visits 1 and 4, and then visits 1 and 7.

Table 4.10: Wilcoxon signed-rank test for ankle dorsiflexion (p-value)

Comparison between visits	Group A n=15	Group B n=15
1-4	0.248	-
1-7	0.480	-

A, Dry needling; B, Shockwave Therapy

Group A analysis:

As reported in table 4.10 above, after the Wilcoxon signed-rank test was performed, there was no statistically significant difference that was noted between the 1st and 4th visits with a p-value of 0.248 (p > 0.025). As for the comparison between the 1st and 7th visits, there were no statistically significant differences reported with a p-value of 0.480 (p > 0.025).

Group B analysis:

Group B reported no statistically significant difference during conduction of the Friedman test, therefore the Wilcoxon signed-rank test was not conducted as no statistically significance would be identified.

Intergroup analysis

The intergroup analysis was conducted using the non-parametric Mann-Whitney U test to determine if there was a difference in measurements between the two groups. These results are reported in table 4.9 above.

The Mann-Whitney U test analysed the ankle dorsiflexion between both groups for visits 1, 4 and 7. The difference between the two groups at visit 1 was **0.588 (p > 0.05)** and was not deemed to be statistically significant. The difference between the two groups at visit 4 was **0.818 (p > 0.05)** and was therefore not deemed to be statistically significant. However, the difference between the two groups at visit 7 was **0.012 (p < 0.05)** and thus was deemed to be statistically significant.

Subsequently, there were only two comparable groups, therefore if a statistically significant difference was noted, no Post-Hoc test was required for further analysis as the difference was noted between the two groups.

Therefore, the mean values are interpreted further, thus on visit 1 group A started with a higher range of motion than group B. However, during visit 4 both groups were similar in their range of motion, with group A increasing significantly during visit 7 while group B decreased.

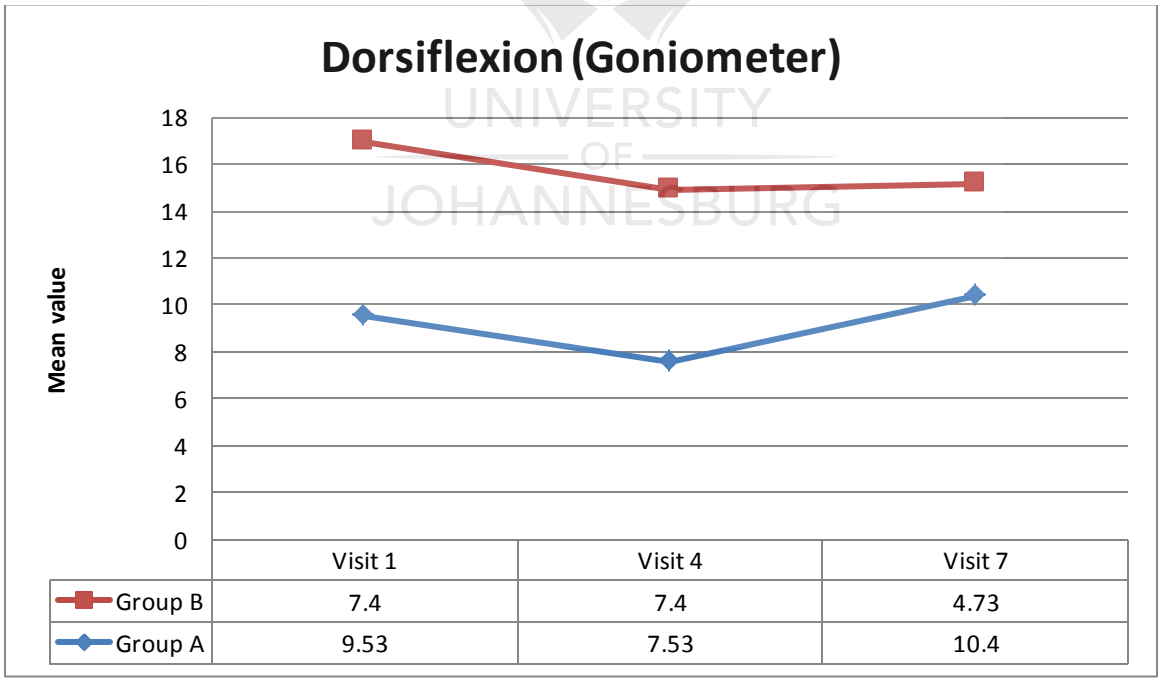


Figure 4.3: Line graph showing the mean dorsiflexion goniometer readings (over visits 1, 4 and 7) for groups A and B

The above line graph (figure 4.3) compares the mean values of the goniometer measurements from visit 1 (first measurements were taken) to visit 4 (second measurement were taken) and visit 7, where the final measurements were taken.

In figure 4.3 above one could depict that for group A there was a decrease in dorsiflexion reading between visit 1 and 4, and a significant increase could be noted between visits 1 and 7. Thus a total increase in the ankle dorsiflexion could be concluded for group A. As for group B between visit 1 and 4 there were no changes in the ankle dorsiflexion that occurred, however between visit 1 and 7 there was a decrease in ankle dorsiflexion noted. Thus a total decrease in the ankle dorsiflexion could be concluded for group B. This would show that group A yielded better results, improving ankle dorsiflexion.

b) Plantarflexion of the ankle joint

The Shapiro-Wilk test was conducted as the preliminary test to determine if the data was of normal distribution.

Table 4.11: Group means and standard deviation - of visits 1, 4 and 7; - for differences between groups; - for differences within groups regarding goniometer readings (plantarflexion)

	Mean value visit 1	Mean value visit 4	Mean value visit 7	Percentage change between 1-7	Difference within groups	Statistical significance
Plantarflexion						
Group A n=15	62.87 (SD ±7.080)	65.20 (SD ±7.043)	68.13 (SD ±8.088)	8.37% Increased	p = 0.003	Significant
Group B n=15	69.27 (SD ±7.015)	70.60 (SD ±6.674)	67.67 (SD ±8.389)	2.31% Decreased	p = 0.408	Not significant
Difference between groups	P = 0.018	p = 0.018	p = 0.868			
Statistical Significance	Significant	Significant	Not significant			

A, Dry needling; B, Shockwave; Range of motion Goniometer (°)

With regards to group A (dry needling) upon visit 1, a mean value of 62.87° (SD± 7.080) was noted, which thus increased to 65.20°(SD± 7.043) upon visit 4, and further increased to 68.13° (SD± 8.088) upon visit 7. Thus an 8.37% improvement in ankle plantarflexion could be deduced between visits 1 and 7.

With regards to group B (shockwave) upon visit 1, a mean value of 69.27° (SD± 7.015) was noted, which thus increased with a mean value of 70.60° (SD± 6.674) upon visit 4, and then further decreased to a mean value of 67.67° (SD± 8.389) upon visit 7. Thus 2.31% reduction in ankle plantarflexion could be deduced between visits 1 and 7.

However there was an increase in ankle plantarflexion throughout the treatment course that could be seen for group A with a 6.4° difference between the two groups starting points. Group B showed that there was a decrease in ankle plantarflexion throughout the treatment course, thus showing that group A yielded a better result clinically with an overall increase in ankle plantarflexion throughout the treatment course. From the 1st visit to the 7th visit, group A had a difference of 5.26° increase in the mean values that was noted, and thus substantiates the above statement.

Intragroup analysis

The Friedman and Wilcoxon signed-rank test was used to analyse the data, which yielded the following results as shown in table 4.11.

There was a statistical significance noted over time in group A with a p–value of **0.003 ($p \leq 0.05$)**. However, there was no statistical significance noted over time for group B with a p-value of **0.408 ($p > 0.05$)**.

As the above statement indicates during the Friedman's tests, there were statistically significant differences reported within the data. Thus the Bonferroni adjustment was applied for the Post-Hoc Wilcoxon signed-rank test. The new reported p-value according to the Wilcoxon signed-rank test was 0.025. Therefore a p-value ≤ 0.025 is suggestive of statistical significance. The Wilcoxon signed-ranks test indicates the comparison of the data between the different visits, comparing visits 1 and 4, and then visits 1 and 7.

Table 4.12: Wilcoxon signed-rank test for ankle plantarflexion (p-value)

Comparison between visits	Group A n=15	Group B n=15
1-4	0.064	-
1-7	**0.005**	-

A, Dry needling; B, Shockwave Therapy

Group A analysis:

As reported in table 4.12 above no statistically significant difference was noted between the 1st and 4th visits with a p-value of **0.064 (p > 0.025)**. As for the comparison between the 1st and 7th visits, there was a statistically significant difference reported with a p-value of 0.005 ($p \leq 0.025$).

Group B analysis:

Group B reported no statistically significant difference during conduction of the Friedman test, therefore the Wilcoxon signed-rank test was not conducted as no statistically significance would be identifiable.

Intergroup analysis

The intergroup analysis was conducted using the non-parametric Mann-Whitney U test to determine if there was a difference in measurements between the groups.

The Mann-Whitney U test analysed the ankle plantarflexion between both groups for visits 1, 4 and 7. The difference between the two groups at visit 1 was $p = 0.018$ ($p < 0.05$) and was deemed to be statistically significant. The difference between the two groups at visit 4 was $p = 0.018$ ($p < 0.05$) and was therefore deemed to be statistically significant. However the difference between the two groups at visit 7 was 0.868 ($p > 0.005$) and thus was not deemed to be statistically significant.

Subsequently, there were only two comparable groups, therefore if a statistically significant difference was noted, no Post-Hoc test was required for further analysis as the difference was between the two groups specifically.

Therefore the mean values are interpreted further, thus on visit 1 group A started with a lower range of motion (ROM) than group B. During visit 4 both groups were at different points, however both groups had an increase in their ROM from visit 1. On visit 7, group A continued to increase in ROM, while group B decreased. Therefore, it could be stated that although group A started at a lower ROM there

was no significant difference by visit 7 between the two groups, indicating that group A caught up to group B.

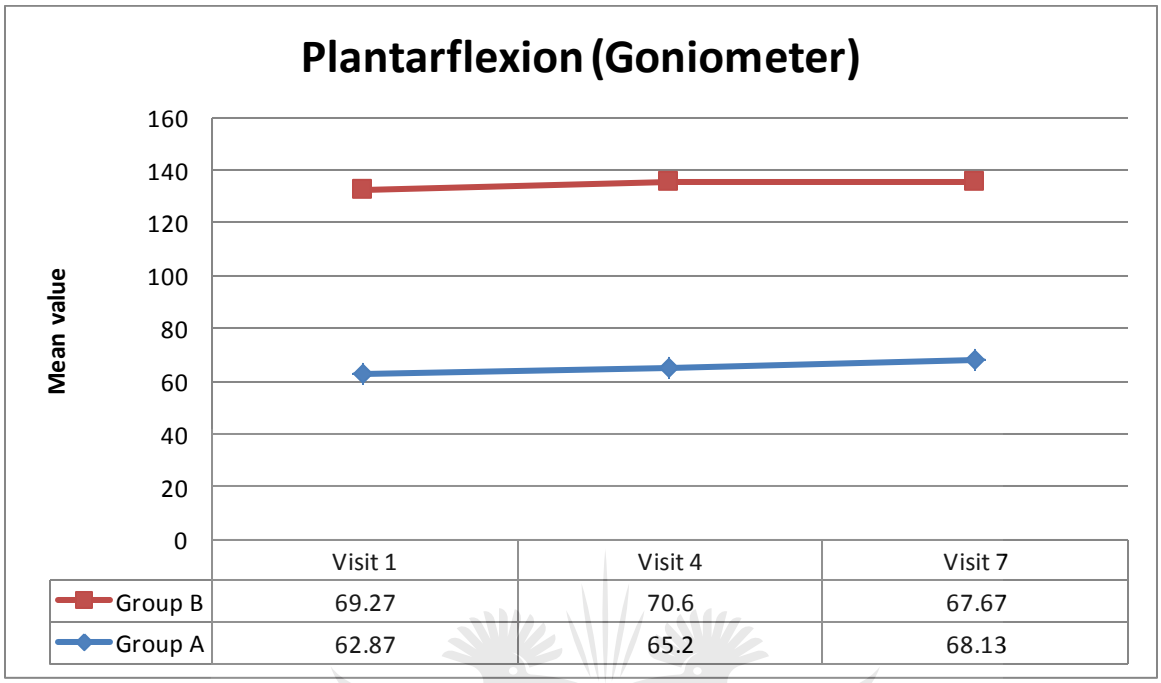


Figure 4.4: Line graph showing the mean plantarflexion goniometer readings (over visits 1, 4 and 7) for groups A and B

The above line graph (figure 4.4) compares the mean values of the goniometer plantarflexion measurements from visit 1 (first measurements were taken) to visit 4 (second measurement were taken) and visit 7, where the final measurements were taken.

In figure 4.4 above one could depict that for group A there was an increase in the plantarflexion reading between visit 1 and 4, and a marked increase could be noted between visits 1 and 7. Thus a total increase in the ankle plantarflexion could be concluded for group A. As for group B between visits 1 and 4 there was an increase in the ankle plantarflexion that occurred, however between visits 1 and 7 there was a significant decrease in ankle plantarflexion noted. Thus a total decrease in the ankle plantarflexion could be concluded for group B. This would show that group A yielded better results, improving ankle plantarflexion.

c) Eversion of the ankle joint

The Shapiro-Wilk test was conducted as the preliminary test to determine if the data was of a normal distribution.

Table 4.13: Group means and standard deviation - of visit 1, 4 and visit 7; - for differences between groups; - for differences within groups regarding goniometer readings (eversion)

	Mean value visit 1	Mean value visit 4	Mean value visit 7	Percentage change between 1-7	Difference within groups	Statistical significance
Eversion						
Group A n=15	11.53 (SD ±7.633)	10.60 (SD ±6.978)	9.13 (SD ±6.128)	20.82% Decreased	p = 0.575	Not significant
Group B n=15	13.60 (SD ±7.209)	9.80 (SD ±3.877)	11.47 (SD ±7.558)	15.66% Decreased	p = 0.528	Not significant
Difference between groups	P = 0.252	p = 1.000	p = 0.270			
Statistical Significance	Not significant	Not significant	Not significant			

A, Dry needling; B, Shockwave; Range of motion Goniometer (°)

With regards to group A (dry needling) upon visit 1, a mean value of 11.53° (SD± 7.633) was noted, which thus decreased to 10.60° (SD± 6.978) upon visit 4 and further decreased to 9.13° (SD± 6.128) upon visit 7. Thus 20.82% reduction in ankle eversion could be deduced between visits 1 and 7.

With regards to group B (shockwave) upon visit 1, a mean value of 13.60° (SD± 7.209) was noted, which thus decreased with a mean value of 9.80° (SD± 3.877) upon visit 4 and then increased from the 4th visit to a mean value of 11.47° (SD± 7.558) upon visit 7, however still decreasing from the 1st visit. Thus 15.66% reduction in ankle eversion could be deduced between visits 1 and 7.

A decrease in ankle eversion throughout the treatment course could be seen for group A with a 2.07° difference between the two groups starting points. Group B showed that there was a decrease in ankle eversion between visits 1 and 4, with an increase in ankle eversion between visits 4 and 7. Conversely, there was an overall decrease throughout the treatment course, thus showing that neither group A or B yielded good results with an overall decrease in ankle eversion throughout the treatment course.

Intragroup analysis

The Friedman and Wilcoxon signed-rank test was used to analyse the data, which yielded the following results as shown in table 4.13.

There was no statistical significance noted over time in group A with a p–value of **0.575 (p > 0.05)**. Conversely, there was no statistical significance was noted over time for group B with a p-value of **0.528 (p > 0.05)**.

As the above statement indicated during the Friedman's tests, there were no statistically significant differences reported within the data. Thus no further analysis of data was necessary, therefore the Wilcoxon signed-rank test was not conducted as no statistically significance would be identifiable.

Intergroup analysis

The intergroup analysis was conducted using the non-parametric Mann-Whitney U test to determine if there was a difference in measurements between the groups.

The Mann-Whitney U test analysed the ankle eversion between both groups for visit 1, 4 and 7. The difference between the two groups at visit 1 was **0.252 (p > 0.05)** and was not deemed to be statistically significant. The difference between the two groups at visit 4 was **1.000 (p > 0.05)** and was therefore not deemed to be statistically significant. Consequently, the difference between the two groups at visit 7 was **0.270 (p > 0.05)** and thus was not deemed to be statistically significant.

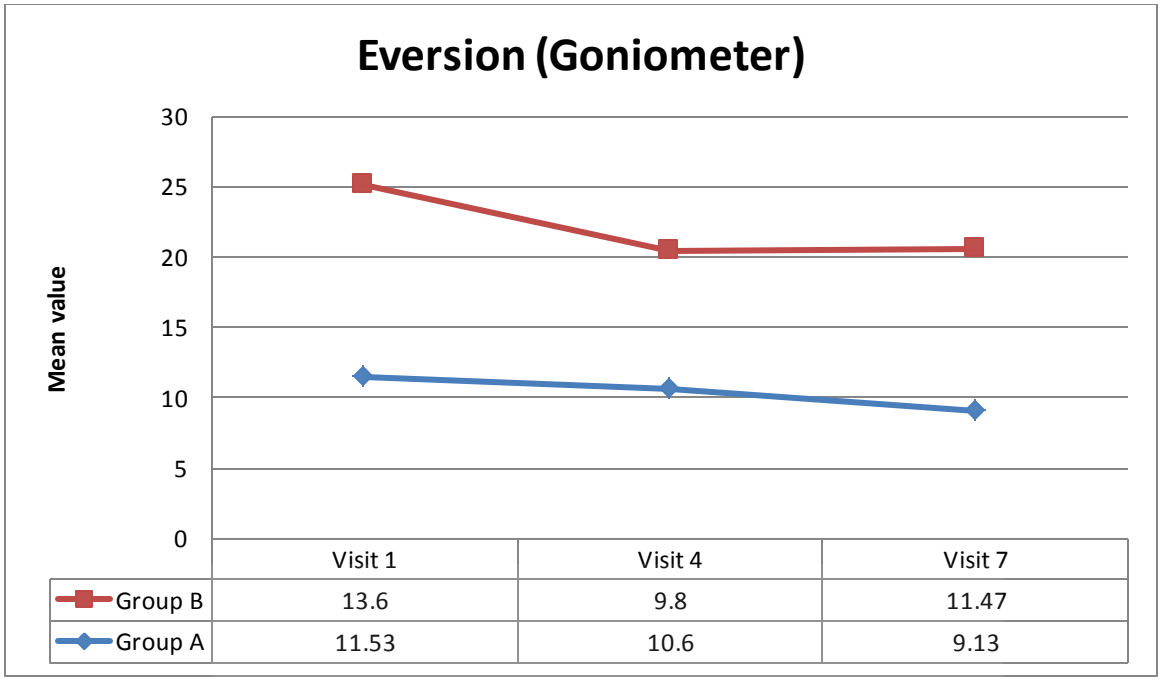


Figure 4.5: Line graph showing the mean eversion goniometer readings (over visits 1, 4 and 7) for groups A and B

The above line graph (figure 4.5) compares the mean values of the goniometer eversion measurements from visit 1 (first measurements were taken) to visit 4 (second measurement were taken) and visit 7, where the final measurements were taken.

In figure 4.5 above one could depict that for group A there was a decrease in eversion reading between visit 1 and 4, and a marked decrease could be noted between visits 1 and 7. Thus a total decrease in the ankle eversion could be concluded for group A. As for group B between visits 1 and 4 there was a decrease in ankle eversion that occurred. However between visits 4 and 7 there was an increase in ankle eversion noted, but between visits 1 and 7 there was a notable decrease in ankle eversion. Thus a total decrease in the ankle eversion could be concluded for group B. This would show that neither group A or B yielded good results, thus there was no improvement in ankle eversion.

d) Inversion of the ankle joint

The Shapiro-Wilk test was conducted as the preliminary test to determine if the data was of a normal distribution.

Table 4.14: Group means and standard deviation - of visits 1, 4 and 7; - for differences between groups; - for differences within groups regarding goniometer readings (inversion)

	Mean value visit 1	Mean value visit 4	Mean value visit 7	Percentage change between 1-7	Difference within groups	Statistical significance
Inversion						
Group A n=15	39.13 (SD ±11.476)	40.53 (SD ±9.303)	41.13 (SD ±13.027)	5.11% Increased	p = 0.933	Not significant
Group B n=15	37.40 (SD ±8.551)	37.13 (SD ±8.535)	38.73 (SD ±9.208)	3.56% Increased	p = 0.932	Not significant
Difference between groups	P = 0.755	p = 0.182	p = 0.633			
Statistical Significance	Not significant	Not significant	Not significant			

A, Dry needling; B, Shockwave; Range of motion Goniometer (°)

With regards to group A (dry needling) upon visit 1, a mean value of 39.13° (SD± 11.476) was noted, which thus increased to 40.53° (SD± 9.303) upon visit 4 and further increased to 41.13° (SD± 13.027) upon visit 7. Thus a 5.11% improvement in ankle inversion could be deduced between visits 1 and 7.

With regards to group B (shockwave) upon visit 1, a mean value of 37.40° (SD± 8.551) was noted, which thus decreased slightly with a mean value of 37.13° (SD± 8.535) upon visit 4 and then further increased to a mean value of 38.73° (SD± 9.208) upon visit 7. Thus 3.56% improvement in ankle inversion could be deduced between visits 1 and 7.

However, there was an increase in ankle inversion throughout the treatment course that could be seen for both groups. There was a discrepancy that could be noted regarding the starting points of both groups, with group A starting at 1.73° higher than group B. Group A showed an initial increase between visits 1 and 4, with a further increase between visits 4 and 7. Group B showed that there was an initial

decrease in ankle inversion between visits 1 and 4, with an increase between visits 4 and 7. Therefore, there was an overall increase throughout the treatment course, thus proving that group A and B yield good results with an overall increase in ankle inversion throughout the treatment course. From the 1st visit to the 7th group A had a difference of 2° increase in the mean value that was noted and group B had a difference of a 1.33° increase, and thus substantiates the above statement proving that both groups showed a clinical significance.

Intragroup analysis

The Friedman and Wilcoxon signed-rank test was used to analyses the data, which yielded the following results as shown in table 4.14.

There was no statistical significance noted over time in group A with a p–value of **0.933 (p > 0.05)**. Also, there was no statistical significance was noted over time for group B either with a p-value of **0.932 (p > 0.05)**.

As the above statement indicates during the Friedman's tests, there were no statistically significant differences reported within the data. Thus no further analysis of data was necessary, therefore the Wilcoxon signed-rank test was not conducted as no statistically significance would be identifiable.

Intergroup analysis

The intergroup analysis was conducted using the non-parametric Mann-Whitney U test to determine if there was a difference in measurements between the groups.

The Mann-Whitney U test analysed the ankle inversion between both groups for visits 1, 4 and 7. The difference between the two groups at visit 1 was **0.755 (p > 0.05)** and was not deemed to be statistically significant. The difference between the two groups at visit 4 was **0.182 (p > 0.05)** and was therefore not deemed to be statistically significant. Consequently, the difference between the two groups at visit 7 was **0.633 (p > 0.005)** and thus was not deemed to be statistically significant.

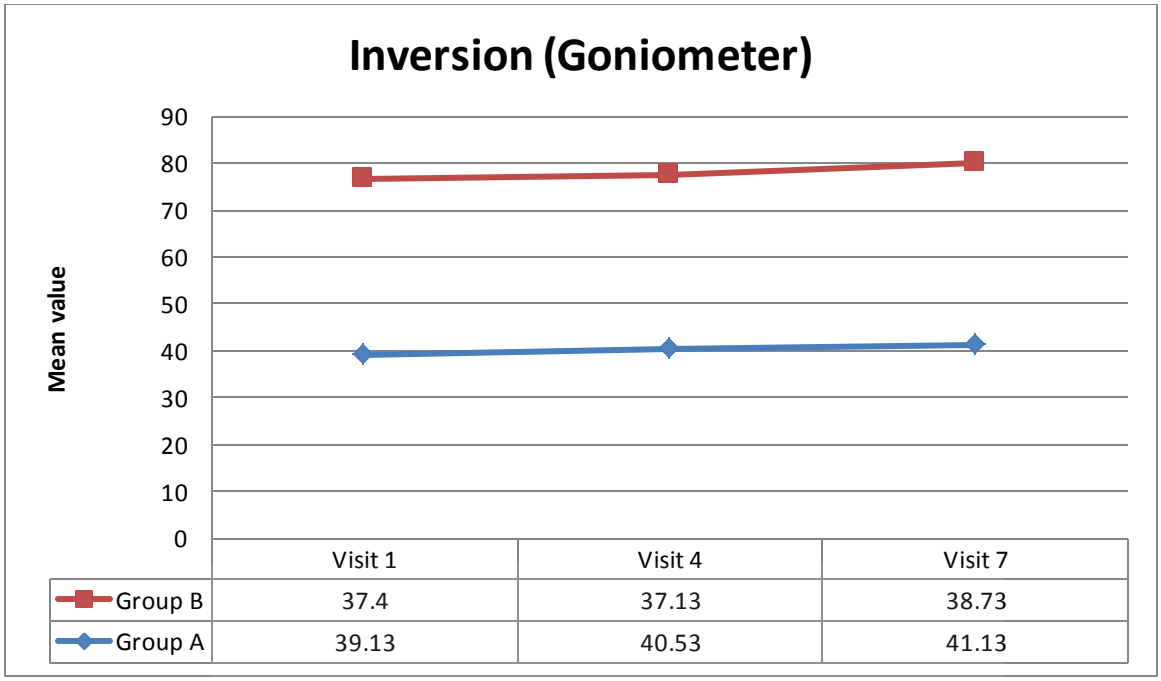


Figure 4.6: Line graph showing the mean inversion goniometer reading (over visits 1, 4 and 7) for groups A and B

The above line graph (figure 4.6) compares the mean values of the goniometer inversion measurements from visit 1 (first measurements were taken) to visit 4 (second measurement were taken) and visit 7, where the final measurements were taken.

In figure 4.6 above one could depict that for group A there was an increase in inversion reading between visit 1 and 4, and a significant increase could be noted between visits 1 and 7. Thus a total increase in the ankle inversion could be concluded for group A. As for group B between visits 1 and 4 there was a slight increase in the ankle inversion that occurred, however between visits 1 and 7 there was a significant increase in ankle inversion noted. Thus a total increase in the ankle inversion could be concluded for group B. This would show that both group A and B yielded good results, improving ankle inversion.

4.6 Conclusion

As could be concluded from the above data, both treatment protocols had a positive effect on the participants' clinically. From a subjective perspective, all participants from both groups had a decrease in their overall perceived pain, as the results from the NPRS indicate. Similarly, the results from the pressure algometer yielded significant results across both groups, as an improvement in trigger point tenderness was noted bilaterally. However, objectively not all ROM were affected positively throughout the clinical trial. Each group yielded different results regarding ROM, which has been further discussed in chapter 5 respectively.

CHAPTER 5 - DISCUSSION

5.1 Introduction

This clinical trial was concerned with exploring the comparative effects of two different soft tissue approaches in the treatment of active peroneal trigger points. This was to establish which soft tissue approach would be the most effective for the treatment of active peroneal trigger points in a patient with a history of a chronic inversion ankle sprain. The intention of this clinical trial was to further aid the way in which inversion ankle injuries were approached in a clinical setting, and possibly prevent ankle trauma from re-occurring.

Chapter five provides a discussion of the key findings from the clinical trial and where applicable, links the literature review to the research outcomes.

The effectiveness of dry needling versus shockwave on myofascial trigger points of the peroneal muscles in terms of pain reduction and improvement in range of motion was tested. The results of this clinical trial were discussed in terms of demographics as well as subjective and objective data within and between groups.

5.2 Demographic Data

The demographic data reflected no statistical significant difference in terms of age, gender, side of injury or proximal or distal trigger points and was therefore comparable. However, the small sample size was not a clear representation of the entire population.

5.2.1 Age

The minimum age was 20 years old, the maximum age was 32 and the average age was 25.27 years old regarding the overall sample size of thirty participants that took part in this clinical trial. Therefore, participants fell within the ideal age bracket (18-35 years old) as per discussed in chapter 3.

It is evident from table 4.1 that the mean age for group A was 25.47 years old and 25.07 years old for group B. The age range was kept consistent throughout the clinical trial therefore, the intergroup analysis of subjective and objective data was not affected by the age distribution between the two groups and the groups were considered to be comparable.

A study carried out in 2010, revealed that there is a higher prevalence of ankle sprains between the age of fifteen and twenty-four years old in males and over the age of thirty in females (Waterman, Owens,

Davey, Zacchilli & Belmont, 2010). The participants in this study fell within this higher risk age group for developing inversion ankle sprains, indicting the sample that was selected fits the ideal age group.

5.2.2 Gender

As shown by table 4.2, group A consisted of four males and eleven females. Group B, consisted of four males and eleven females. Gender was a demographic factor that was controlled and evenly distributed between the two groups to encourage validity of the data obtained. Gender was kept equal between the two groups to eliminate gender differences affecting the outcome of the results. A total of eight males which constituted 26.7% and twenty two females which constituted 73.3% out of the total number of thirty participants that took part in this study. As gender was represented equally across both groups, the two groups were considered to be comparable.

The risk factors for acute and chronic lateral ankle instability include athletic activity, female gender, elevated body weight or body mass index, neuromuscular deficits, foot/ankle malalignment, postural imbalance, and prior ankle sprain (McCriskin, Cameron, Orr & Waterman, 2015). This clinical trial included more female participants than male, therefore, the gender distribution of this study was in line with the proposed risk factors of developing a chronic inversion ankle sprain.

5.2.3 Side of treatment/injury

There were five participants in total with a history of left hand side inversion ankle sprains and twenty five with a history of right hand side inversion ankle sprains. This data was shown in table 4.3.

5.2.4 Peroneus longus/brevis trigger points

As shown in table 4.4, group A had nine participants that had active trigger points in peroneus longus and six participants that had active trigger points in peroneus brevis. Group B, had fourteen participants that had active trigger points in peroneus longus and one participant that had active trigger points in peroneus brevis. Therefore, a total of twenty three participants had active trigger points in peroneus longus and a total of seven participants had active trigger points in peroneus brevis. Thus, in this study a conclusion could be made that there is a higher prevalence of active trigger points in peroneus longus than there is in peroneus brevis that is linked to chronic ankle inversion sprains. However, the small sample size was not a clear representation of the entire population.

Chronic ankle instability has been associated with changes in soft tissue function that may arise in the surrounding musculature. A study by Hoch and Mckeon in 2014, noticed that subjects who presented with ankle instability also presented with a delayed peroneal reaction time when compared to the

contralateral uninjured ankle. This further suggests the presence of muscle control disturbances in the surrounding musculature in patients with ankle instability. Furthermore, repetitive ankle trauma has been proposed as one of the potential mechanism for activation of myofascial trigger points (Salom-Moreno, *et al*., 2015). There have been no studies on which specific muscles were more prone to developing myofascial trigger points following ankle trauma. However, it is known that the peroneal muscle group is primarily involved. On the other hand, it is known that neuromuscular control is essential for dynamic stability of the ankle joint and includes both reflexes and voluntary muscle responses. The reflex responses results in a sudden change in muscle length and this sudden change in speed would be identified by the muscle spindles of the muscles being stretched (e.g., peroneal muscles) during a sudden ankle inversion movement (Hung, 2015). This could explain the prevalence of active peroneal trigger points that accompany inversion ankle sprains.

5.3 Subjective Data Discussion

The subjective data was captured using the NPRS. In which the self-reported pain intensity was reported at visits 1, 4 and 7. Group A received dry needling to the most active trigger point of the peroneal muscle group while, group B received shockwave therapy to the most active trigger point of the peroneal muscle group.

5.3.1 Numerical Pain Rating Scale

Clinical interpretation

As per the results tabulated in table 4.5, which yielded positive results clinically. Thus both groups' treatment methods were considered clinically significant as there was a decrease in overall perceived pain throughout the treatment sessions that were observed.

Intergroup analysis

At visit 1, the difference in the NPRS values between group A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 4, the difference in NPRS values between groups A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 7 (final visit), the difference in NPRS values between groups A and B were not considered to be statistically significant. Therefore, both groups were still comparable at this point. In other words, neither

group yielded superior results over the other showing no clinical significance. Thus neither dry needling nor shockwave therapy was more effective than the other in decreasing the NPRS scores.

The results as mentioned above showed that clinically there was an improvement in pain interpretation of the participants between visits 1 and 4, and visits 1 and 7. This indicated that there was an overall improvement clinically throughout all the treatment sessions for both groups. This could be due to the therapeutic effects of dry needling and shockwave therapy on the active trigger points of the peroneal trigger points.

Intragroup analysis

The analysis of each group between visits 1 and 7 showed an 80.95% increase in NPRS values for group A, with a 73.54% increase in NPRS values for group B. For group A, the change was regarded statistically significant indicating that dry needling is effective in decreasing the participant's perceived pain over time. For group B, the change was regarded statistically significant indicating that shockwave therapy is effective in decreasing the participant's perceived pain over time. Therefore, both treatment methods were successful in decreasing the participant's perceived pain and are regarded as clinically significant.

Table 5.1: Percent change with regards to NPRS readings for both groups

	Group A		Group B	
	Decreased	**Increased (%)**	**Decreased**	**Increased (%)**
NPRS Readings	3.4	80.95	3.14	73.54

*a decrease in NPRS reading indicates an improvement

Discussion

From the results mentioned above, a general consensus could be concluded that there was a decrease in overall perceived pain from both groups. However, group A yielded the superior results clinically as compared to group B. There was a 3.4 difference on the NPRS noticed between the first and last visits for group A, with a 3.14 difference noticed on the NPRS between the first and last visits for group B.

As discussed in chapter 2, dry needling has an effect on pain reduction. Additionally, Ceccherelli (2002) proposed that muscle afferents could be more significant than skin afferents for the transmission of analgesic signals. Similarly, Itoh (2007) suggested that the occurrences of polymodal-type receptors (near the MTrPs) are responsive to mechanical, thermal, and chemical stimuli. Thus, needle penetration stimulates such receptors in the muscle to yield stronger effects on pain relief. Conversely, these same receptors have been suggested to be present in the dermis, and may account for the analgesic effects post stimulation of the dermis by penetration of the needles (Tekin, Akarsu, Durmuş, Çakar, Dinçer & Kıralp, 2013).

A study that was done, established that the effects of deep dry needling were largely due to the mechanical stimulation of MTrPs. Dating back to as early as 1944, researchers had found that deep dry needling was effective on musculoskeletal pain without the use of an injectable substance. It was established that dry needling of MTrPs causes an immediate analgesic effect in approximately 87% of the needle site. The analgesia was long-lasting, in over 31% of cases noted. While 20% only had several months of pain reduction that could be noted, 22% were noted only lasting several weeks, 11% lasted several days, and 14% had no relief at all (Fernández-de-las-Peñas & Dommerholt, 2014).

Taking into consideration the mechanotransduction effect of ESWT in other diseases, it could be proposed that ESWT in myofascial pain syndrome may induce angiogenesis, increased perfusion, and modify the pain signalling in ischaemic tissues as a result of an increase in calcium irons. In contrast, recent articles have found that free nerve endings degenerate after the application of ESWT, and that ESWT produces a transient dysfunction of nerve excitability at the neuromuscular junction, by bringing about the degeneration of acetylcholine receptors (AChR) (Ramon *et al*., 2015).

The results from the clinical trial suggest that shockwave therapy is successful in reducing pain. With that said, based on findings of a similar study, the effectiveness of focused ESWT on MTPs, resulted in pain reduction in 95% of the 30 patients in a group over a 3 month period (Müller-Ehrenberg & Licht, 2005). This further supports the aim of this clinical trial.

5.4 Objective Data Discussion

The objective data was collected using the pressure algometer to measure trigger point tenderness of the peroneal muscles and the goniometer to measure ankle range of motion.

5.4.1 Pressure algometer

Clinical interpretation

For this study the pressure algometer was used to measure the participant's pain pressure threshold (PPT) on visits 1, 4 and 7. An increased reading between treatments indicates an improvement of pain threshold and thus a decrease in trigger point tenderness. However, a decrease in pressure algometer readings between treatments was an indication of a decline in pain threshold and worsening of trigger point tenderness.

Inter-group analysis

At visit 1, the difference in the PPT values between group A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 4, the difference in PPT values between groups A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 7 (final visit), the difference in PPT values between groups A and B were not considered to be statistically significant. Therefore, both groups were still comparable at this point. In other words, neither group yielded superior results over the other showing no clinical significance. Thus, neither dry needling nor shockwave therapy was more effective than the other in increasing the participants PPT.

The results as mentioned above suggest that clinically there was an improvement in PPT of the participants between visits 1 and 4, and visits 1 and 7. This indicates that there was an overall improvement clinically throughout all the treatment sessions for both groups. This could be due to the therapeutic effects of dry needling and shockwave therapy on the active trigger points of the peroneal trigger points.

Intra-group analysis

The analysis of each group between visits 1 and 7 showed a 32.46% increase in PPT values for group A, with a 40.47% increase in PPT values for group B. For group A, the change was regarded statistically significant indicating that dry needling is effective in increasing the PPT over time. For group

B, the change was regarded statistically significant indicating that shockwave therapy is effective in increasing the participant's PPT over time. Therefore, both treatment methods were successful in increasing the participant's pain threshold and are regarded as clinically significant.

Table 5.2: Percentage change with regards to pressure algometer readings for both groups

	Group A		Group B	
	Increased (km/cm²)	**Increased (%)**	**Increased (km/cm²)**	**Increased (%)**
Pressure Algometer Readings	3.4	32.46	3.14	40.47

*an increase in the pressure algometer reading indicates an improvement

Discussion

Consequently, from the results mentioned above, a general consensus could be concluded that there was an increase in overall pain threshold from both groups indicating a decrease in trigger point tenderness. However, group B yielded the better results clinically in comparison to group A. There was a 1.11 km/cm² difference noticed between the first and last visits for group A, with a 1.38 km/cm² difference noticed between the first and last visits for group B. Both groups started at more or less the same point on the initial reading however, group B surpassed group A with regards to increasing pain threshold.

A substantial reduction in pressure sensitivity supports the segmental antinociceptive effect of deep dry needling. A study that was done, suggested that a widespread change in pressure pain sensitivity post application of a needle in patients who had experienced a stroke, proposing a central effect (Mendigutia-Gómez, Martín-Hernández & Fernández-de-las-Peñas, 2016).

Regarding, myofascial pain syndrome and the energy crisis hypothesis that has been linked to the formation of trigger points. It has been proposed that shockwave therapy was able to break up Actin-Myosin links, as they are propagating perpendicularly to the sarcomere contractions (Ramon, *et al*., 2015). Therefore, this could be suggestive of the reduction in the participant's perceived pain that was observed in group B. This could be due to the fact that the myofascial trigger point was being broken down as a result of the effects of shockwave therapy on the Actin-Myosin links that result in the taut band and thus reducing the tenderness that was experienced when the active trigger point was present in the peroneal muscles.

5.4.2 Goniometer

Range of motion of the ankle joint

For this clinical trial dorsiflexion, plantarflexion, eversion and inversion were measured using a manual goniometer. The normal ranges of motion for the ankle joint were discussed in chapter 2.

a) Dorsiflexion of the ankle joint

Intergroup analysis

At visit 1, the difference in the dorsiflexion values between group A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 4, the difference in dorsiflexion values between groups A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

However, at visit 7 (final visit), the difference in dorsiflexion values between groups A and B were considered to be statistically significant.

This indicates that the two groups started off comparable during the first and fourth visit but were not deemed comparable by the seventh visit. The difference of the goniometer values for ankle dorsiflexion between the two groups at the final visit was significant enough to determine which soft tissue modality was of greater clinical significance. Thus, dry needling yielded better results indicating an increase in ankle dorsiflexion. However, shockwave therapy did not yield clinically significant result in terms of increasing ankle dorsiflexion, as there was a decrease that could be noted.

Intragroup analysis

The analysis of each group between visits 1 and 7 showed a 9.13% increase in dorsiflexion values for group A, with a 36.08% decrease in dorsiflexion for group B. For group A, the change was regarded clinically significant indicating that dry needling is effective in increasing dorsiflexion over time. However, for group B, there was no clinical significance that could be noted as there was a decrease in dorsiflexion over time. This indicates that shockwave therapy was not effective in increasing dorsiflexion over time.

Consequently, from the results mentioned above, a general consensus could be concluded that there was an increase in overall ankle dorsiflexion with regards to group A. However, regarding group B there was an overall decrease in ankle dorsiflexion that could be noted. Therefore, group A yielded the better

results clinically in comparison to group B. There was a 0.87° increase that could be observed between the first and last visits for group A, contrary a 2.67° decrease could be observed between the first and last visits for group B. Group A initially stated off with a higher ankle dorsiflexion range of motion in comparison to group B.

b) Plantarflexion of the ankle joint

Intergroup analysis

At visit 1, the difference in the plantarflexion values between group A and B were considered to be statistically significant. Therefore, both groups were not considered comparable at this point.

At visit 4, the difference in plantarflexion values between groups A and B were considered to be statistically significant. Therefore, both groups were not considered comparable at this point.

However, at visit 7 (final visit), the difference in plantarflexion values between groups A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point. In stating that, neither of the two groups showed a superior clinical significant result over the other in terms of an increase in plantarflexion.

The difference of the goniometer values for ankle plantarflexion between the two groups at the final visit was not significant enough to determine which soft tissue modality was of greater clinical significance. Thus, neither dry needling nor shockwave therapy was more effective than the other in increasing the ankle plantarflexion.

The results as mentioned above suggests that clinically there was an overall improvement in ankle plantarflexion of the participants between visits 1 and 4, and visits 1 and 7 regarding group A. Group B showed an initial increase in ankle plantarflexion between visits 1 and 4. However, group B decreased between visits 1 and 7. This indicates that there was an overall increase in plantar flexion for group A. As for group B, there was an initial increase in ankle plantarflexion, with an overall decrease in ankle plantarflexion throughout all the treatment sessions. This could be due to the therapeutic effects of dry needling on the active trigger points of the peroneal trigger points.

Intragroup analysis

The analysis of each group between visits 1 and 7 showed an 8.37% increase in plantarflexion values for group A, with a 2.31% decrease in plantarflexion for group B. For group A, the change was regarded clinically significant indicating that dry needling is effective in increasing plantarflexion over time.

However, for group B, there was no clinical significance that could be noted as there was a decrease in plantarflexion over time. This indicates that shockwave therapy was not effective in increasing plantarflexion over time.

Consequently, from the results mentioned above, a general consensus could be concluded that there was an increase in overall ankle plantarflexion with regards to group A. However, regarding group B there was an overall decrease in ankle plantarflexion that could be noted. Therefore, group A yielded the better results clinically in comparison to group B. There was a 5.26° increase that could be observed between the first and last visits for group A, contrary a 1.6° decrease could be observed between the first and last visits for group B. Group A initially started off with a higher ankle dorsiflexion range of motion in comparison to group B.

c) Eversion of the ankle joint

Intergroup analysis

At visit 1, the difference in the eversion values between group A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 4, the difference in eversion values between groups A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 7 (final visit), the difference in eversion values between groups A and B were not considered to be statistically significant. Therefore, both groups were still comparable at this point. In other words, neither of the two groups showed a superior clinical significant result over the other in terms of an increase in eversion.

Intragroup analysis

The analysis of each group between visits 1 and 7 showed a 20.82% decrease in eversion for group A, with a 15.66% decrease in eversion for group B. For group A, the change was not regarded clinically significant indicating that dry needling is not effective in increasing eversion over time. Group B, was also granted not clinically significant as there was a decrease in eversion over time. This indicates that neither dry needling nor shockwave therapy was effective in increasing eversion over time.

Consequently, from the results mentioned above, a general consensus could be concluded that there was decrease in overall ankle eversion regarding both groups. There was a 2.4° decrease that could be

observed between the first and last visits for group A, contrary a 2.13° decrease could be observed between the first and last visits for group B.

d) Inversion of the ankle joint

Intergroup analysis

At visit 1, the difference in the inversion values between group A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 4, the difference in inversion values between groups A and B were not considered to be statistically significant. Therefore, both groups were comparable at this point.

At visit 7 (final visit), the difference in inversion values between groups A and B were not considered to be statistically significant. Therefore, both groups were still comparable at this point. In other words, neither of the two groups showed a superior clinical significant result over the other in terms of an increase in inversion.

Intragroup analysis

The analysis of each group between visits 1 and 7 showed a 5.11% increase in inversion for group A, with a 3.56% increase in inversion for group B. For group A, the change was regarded as clinically significant indicating that dry needling is effective in increasing inversion over time. As for group B, there was a clinical significance that could be noted as there was an increase in inversion over time as well. This indicates that both dry needling and shockwave therapy are effective in increasing inversion over time.

Consequently, from the results mentioned above, a general consensus could be concluded that there was an increase in overall ankle inversion regarding both groups. There was a 2° increase observed between the first and last visits for group A. As well as a 1.33° increase could be observed between the first and last visits for group B. Suggesting that both dry needling and shockwave therapy was effective in increasing ankle inversion throughout the treatment sessions.

Table 5.3: Percentage change with regards to goniometer readings for ankle dorsiflexion, plantarflexion, eversion and inversion for both groups

Range of motion	Group A		Group B	
	Increased (°)	Increased (%)	Decreased (°)	Decreased (%)
Dorsiflexion Readings	0.87	9.13	2.67	36.08%
	Group A		**Group B**	
	Increased (°)	Increased (%)	Decreased (°)	Decreased (%)
Plantarflexion Readings	5.26	8.37	1.6	2.31%
	Group A		**Group B**	
	Decreased (°)	Decreased (%)	Decreased (°)	Decreased (%)
Eversion Readings	2.4	20.82	2.13	15.66%
	Group A		**Group B**	
	Increased (°)	Increased (%)	Increased (°)	Increased (%)
Inversion Readings	2	5.11	1.33	3.56%

Overall discussion for ankle range of motion

It has been suggested that normal ankle range of motion is estimated at 20° of dorsiflexion and 50°of plantarflexion. A combination of plantarflexion and dorsiflexion on average is 24° to 30° and is required for a normal gait pattern. When ascending stairs a combined average of 37° is needed and for descending stairs a combined average of 55° is needed. Therefore, a decreased range of motion of the ankle joint can lead to a dysfunction in gait (Coetzee & Castro, 2004). Inversion ankle sprains and the development of active trigger point in the peroneal muscle can lead to a decreased range of motion of the ankle joint (Simons *et al*., 2019). The rate of ankle re-injury is 28.3 percent and could lead to a condition known as chronic ankle instability (CAI), which could be described as repetitive ankle sprains and persistence of the symptoms after injury (Pietrosimone *et al*., 2012).

CAI could lead to restrictions in daily life and sporting activities, it is characterised by the subjective feeling of the ankle giving away and the recurrent occurrence of pain, swelling and re-sprain. There are several known contributing factors to CAI. These include mechanical impairments such as altered joint kinematics, laxity within the joint, and degenerative changes to the cartilage of the talocrural joint or functional impairments such as deficits in strength, proprioception and muscle control. The surrounding musculature has been known to play a role in the aetiology of CAI, as it has been suggested that alterations in the soft tissue function may lead to CAI. A study that was done established that patients presenting with CAI demonstrated delayed peroneal reaction time in comparison to the uninjured side. This further supports the statement that muscle control disturbances in the surrounding musculature are present in patients with ankle instability (Salom-Moreno *et al*., 2015).

It has been suggested that repetitive ankle injuries are a probable mechanisms for activation of MTrPs. Altered motor control patterns and accelerated muscle fatigability have been linked to the presence of MTrPs (Salom-Moreno, *et al*., 2015). MTrPs can be described as latent or active trigger points. Active MTrPs may be accountable for the production of local pain and/or referred pain. This could in turn lead to altered muscle activation patterns which may result in limited range of motion or weakness of the involved muscles (Mason, Crowell, Dolbeer, Morris, Terry, Koppenhaver & Goss, 2016).

Therefore, it is essential that the peroneal muscles are addressed in the treatment and rehabilitation protocol for inversion ankle sprains. Proper treatment of MTrPs may successfully decrease the motor disturbances in the affected musculature that have been associated with the development of MTrPs, by preventing overload spreading to the surrounding structures. Trigger point dry needling has been suggested to be a successful therapeutic approach for the management of the sensory and motor deficits that are associated with MTrPs (Salom-Moreno *et al*., 2015).

In this clinical trial, the approach to treating active trigger points in the peroneal muscles was tested to determine which soft tissue modality was more effective, in participants with chronic inversion ankle sprains. This would be beneficial in the rehabilitation protocol of chronic ankle sprains to reduce dysfunction, improve overall range of motion of the injured ankle, and prevent further injury or re-injuries and the development of CAI.

Overall group A, which received myofascial dry needling to the most active peroneal trigger point, had an increase in dorsiflexion, plantarflexion and inversion. Whereas group B, received shockwave to the most active peroneal trigger point, only had an increase in inversion. This goes to show that myofascial dry needling has more clinical significance than shockwave in improving the ankle's overall range of motion.

The overall increase in range of motion that occurred with myofascial dry needling, as per discussed previously in chapter two, could be explained as a result of the mechanical disruption that occurs within the myofascial trigger point once the needle has been inserted directly into the MTrPs and the twitch response is elicited. This could be further explained, when a needle is inserted directly into a myofascial trigger point the needle may induce a localized stretch to the contractured cytoskeletal structures. This allows the sarcomeres that are involved to return back to their original resting length by reducing the degree of overlapping actin and myosin filaments. Rotation of the needle would allow increased localized stretch to the contractured structures that would enhance the effectiveness (Dommerholt *et al*., 2011). This phenomenon of returning the sarcomeres back to their resting length could explain the increase in dorsiflexion, plantarflexion and inversion that was experienced in group A.

Insertion of a needle into a myofascial trigger point results in a local twitch response. This is a quick contraction and relaxation of the myofascial trigger point fibres, and is associated with the neuromuscular and biochemical benefits that aid in the improvement of flexibility of the muscle-tendon unit (Jayaseelan, Moats & Ricardo, 2014). It has been suggested that dry needling is most effective when the local twitch response is produced. This could be related back to the fact that a rapid depolarization of the muscle fibres occurs, which manifests as a local twitch response. Once the twitching of the muscle has ended, the spontaneous electrical activity subsides and dysfunction declines (Kalichman & Vulfsons, 2010). This could further explain the increase of range of motion that was experienced with group A, as the dysfunction within the muscle was restored back to its normal functioning state.

The results of this clinical trial could build on existing evidence that the increase in range of motion of the ankle joint could be as a result of the decrease in muscle stiffness and thus a decrease in muscle resistance to passive range of motion. This improvement in range of motion may be linked to a decreased in muscle tension with dry needling, however further research needs to be conducted (Mendigutia-Gómez *et al*., 2016).

In two previous studies that were done, an increase in cervical range of motion was noted as an effect of dry needling. The first study compared the differences between the effectiveness of local injections of lidocaine and dry needling on pain, cervical ROM, and depression in MFPS patients. During this study a significant increase was obtained in every direction in the first and third months in cervical ROM in both groups respectively (Ay, Evcik & Tur, 2010). The second study compared the effects of trigger point dry needling (TrPDN) on neck pain, widespread pressure pain sensitivity, and cervical range of motion in patients with acute mechanical neck pain and active trigger points in the upper trapezius

muscle. During this study a conclusion was made that a single treatment session of dry needling of the myofascial trigger points in the trapezius muscle leads to a clinically significant increases in cervical range of motion (Espejo-Antúnez, Tejeda, Albornoz-Cabello, Rodríguez-Mansilla, Cruz-Sánchez, Ribeiro & Silva, 2017).

However, with regards to group B shockwave did not yield the results as hoped as no improvement in overall ankle range of motion was established throughout the treatment period.

Myofascial trigger points within a muscle results in pain which in turn prevents the muscle from reaching its full stretch range of motion, strength and endurance (Simons & Travell, 2001). It has been said that eliciting a local twitch response within the muscle results in the most effective results when treating a MTrP (Kalichman *et al*., 2010). There has been no evidence suggesting that shockwave therapy results in a local twitch response. This could be suggestive as to why shockwave therapy was not successful in increasing ankle range of motion when shockwave therapy was applied to the most active trigger points in the peroneal muscles.

Contrary to the results of this study, one study proved that shockwave therapy does increase the range of motion. This study compared the effectiveness of shockwave therapy versus mobilization with movement on patients with knee osteoarthritis. However, this study incorporated a combination of exercise and ESWT (Magdolin & Shenouda, 2013). This would suggest that a multilateral treatment approach, could be more effective than just shockwave therapy by its self as the desired treatment approach for treating myofascial trigger points to induce an effect on overall ankle range of motion.

The results of this study build on existing evidence of another study that was done, reviewed the effectiveness of shockwave therapy for MFPS, paying attention to MTrPs and fibromyalgia. The study involved two groups of fifteen participants each presenting with myofascial pain syndrome in the upper trapezius muscle. One group of fifteen were subjected to treatment with the use of TENS combined with an injection into the trigger point once a week. And the second group of fifteen was subjected to treatment using extracorporeal shock wave lithotripsy (ESWL) once every 3 weeks. No significant difference in neck ROM was noted at the end of the study (Jeon *et al*., 2012). This further suggests that shockwave may not have the clinical effect on range of motion that we had hoped to substantiate the aim of this clinical trial.

5.5 Overall Discussion

As per discussed above, with regards to perceived pain and trigger point tenderness reduction, taking the NPRS and PPT results into consideration for both groups, bilaterally both groups showed a clinically and statistically significant improvement that was noted throughout the treatment sessions. In saying that, no group was more effective than the other. Therefore, the aim of the study was inconclusive in determining which treatment method was more effective in reducing perceived pain and overall tenderness of the active trigger point as both groups were equally as effective.

The ankle joint is involved in gait and is essential for bipedal individuals for carrying out daily tasks. Ankle sprains are common occurrences amongst individuals during sporting activities, out of the individuals who experience ankle sprains 40% of them develop into CAI. CAI could lead to reduced reflex excitability of the stabilizing muscles of the ankle, this in turn leads to a clinical impairment in gait, balance and pre-existing function (Pietrosimone *et al*., 2012). Development of active myofascial trigger point in the peroneal muscles is commonly linked with inversion ankle sprains and could result in primary dysfunction (Simons *et al*., 2019). Therefore, it is essential to establish the correct rehabilitation protocol and restore ankle range of motion to re-establish functionality of the injured ankle joint.

As discussed above ankle dorsiflexion, plantarflexion and inversion increased through the use of dry needling as the therapeutic modality for group A. As for shockwave, which was used as the therapeutic modality for group B, only inversion increased. Therefore, we can suggest that dry needling was more effective in increasing overall range of motion in comparison to shockwave therapy. In line with the aim of this clinical trial, a pervious study that was done proposed that myofascial dry needling has been shown to decrease pain and muscle tension, improved range of motion, muscle strength and coordination (Cagnie, Dewitte, Barbe, Timmermans, Delrue & Meeus, 2013).

Group B which received shockwave therapy was inconclusive as it was effective in reducing perceived pain and trigger point tenderness however, it was inadequate in improving range of motion. In which the results of this clinical trial contradicts the claims of Bauermeister (2005) and Shah (2008), where shockwave therapy was regarded as a treatment method that has been shown to be effective in the treatment of myofascial trigger points (Bauermeister, 2005). Shockwave therapy has shown to be effective in promoting angiogenesis, increasing profusion, enhancing cell differentiation, decreasing inflammation and alleviating pain by altering pain signals (Shah & Gilliams, 2008). Thus, no research has been suggestive of shockwave therapy having an effect of ROM.

As deduced throughout chapter 5, both treatment modalities have the potential to be effective in reducing pain and perceived pain as a result of a myofascial trigger points by deactivating or breaking down the trigger point. However, lack of clinically significant differences between the two treatment methods could be noted regarding reduction in tenderness and perceived pain of the MTrP. On the other hand, regarding ankle range of motion, dry needling yielded the best results improving three out of the four ranges of motion in comparison to shockwave only improving one. Therefore, we can conclude that dry needling was more effective in improving ankle range of motion and would be better suited to be implicated into a rehabilitation protocol. This clinical trial provides new insight into the approach in which chronic ankle sprains could be treated. The results of this clinical trial build on pre-existing evidence that dry needling has an effect on ROM, perceived pain and trigger point tenderness.

CHAPTER 6 - CONCLUSION

6.1 Introduction

In this chapter the conclusion, was drawn from the study and was based on chapter 5, has been discussed. Recommendations for related studies to be done in the future and improvements that could have improved the study are discussed, including the limitations that presented during this study.

6.2 Conclusion

This study explored the comparative effects of two different soft tissue approaches in the treatment of active peroneal trigger points in patients with a history of a chronic inversion ankle sprain. The data from the two different groups were analyzed to establish which soft tissue approach was the most effective.

This study focused on the effects of dry needling (group A) and shockwave therapy (group B) on peroneal muscle trigger points tenderness (pain threshold), perceived pain and ankle range of motion. Regarding perceived pain, there was a decrease that was noted for both treatment groups, as both groups yielded a positive clinical result. The trigger point tenderness (pain threshold) concerning both groups increased concluding that both groups yielded a positive result clinically. Thus, both dry needling and shockwave therapy resulted in an increase in the participant's pain threshold, which was indicative of an overall decrease in pain of the active peroneal trigger points over the six treatment sessions. The overall decrease in pain of the active peroneal trigger points as indicated by a decrease in perceived pain and pain threshold of the participants, suggested that although both treatment protocol had positive effects on the participants over the six visits, neither treatment protocols had definitive statistical improvements compared to the other in the treatment of chronic inversion ankle sprains.

The goniometer readings however, were feeble and did not produce a positive clinical result for both groups. The treatment group that received dry needling had an increase in ankle range of motion, specifically ankle dorsiflexion, plantarflexion and inversion. However, the treatment group receiving shockwave therapy only had an increase in ankle inversion.

Therefore, dry needling was shown to be more effective in improving ankle range of motion related to a chronic inversion ankle sprain, as shockwave yielded poor results regarding improving range of motion.

To conclude, both treatment protocols were effective in reducing pain of the active peroneal trigger point. However, dry needling showed to be more effective in improving the overall range of motion of the ankle. This concludes that dry needling could be successfully implicated into a rehabilitation protocol for the treatment of chronic ankle sprains as to prevent chronic ankle instability and maintain a pain free and improved range of motion.

6.3 Limitations

Multiple aspects contributed to the limitations that were experienced during this clinical trial to obtain the most accurate results possible. The goniometer, although deemed reliable and valid for measuring the ankle range of motion when the same practitioner was using the measuring device, provided difficult in yielding similar measurements when trying to obtain the mean value of three different readings taken straight after each other.

The inconsistencies regarding the setting in which the shockwave machine was applied was not ideal, as the machine was set to the participant's tolerance and was not consistent. There have been multiple studies on the effects of shockwave therapy, however no standardization protocol exists for the treatment of musculoskeletal pathologies. The variables differ for each study recorded, which included number of impulses, device used, energy flux density, type of wave (radial or focal), days between sessions, number of treatments, area of application, and use of analgesia for the period of application. Therefore, as shockwave therapy has shown to have a dose-dependent effect, the use of different intensities and impulses may have had an effect on the treatment results.

Other factors that limited the results to be as accurate as possible are variables that could have played a role however, could not be controlled. These variables included limitation of participant's activity or sporting hobbies outside the trial which could have added to the participants myofascial pain syndrome (MFPS) and formation of active trigger points in other nearby muscles.

6.4 Recommendations

The recommendations below could aid in future research pertaining to myofascial trigger points and the use of shockwave therapy or dry needling, or for the treatment of chronic inversion ankle sprains:

- The inclusion of additional follow up visits at an interval periods of two week and one month post treatment to determine the long term effects for each protocol. This could determine which treatment protocol has longer lasting clinical effects on ankle range of motion and myofascial trigger points.
- A clinical study could be done using shockwave therapy at different intensities and impulses to determine which setting has a better clinical effect on treating myofascial trigger points.
- A comparative study could be done which includes the addition of post stretch protocols or proprioceptive exercises along with the application of shockwave and dry needling therapy to the active peroneal trigger point.
- A comparative study could be done to compare the effects of voodoo flossing of the ankle and the effects on range of motion and pain reduction, to determine the best rehabilitation protocol for chronic inversion ankle sprains.
- Future studies could be conducted on specific population groups, i.e. gender to compare the differences in pain threshold and speed of healing or a specific sporting group, in order to collect information of rehabilitation protocols for chronic inversion ankle sprains on a broader spectrum.
- The range of motions that are measured could be limited to the actions which are produced by the peroneal longus and brevis muscles, i.e. plantarflexion and eversion only, instead of all motions of the ankle joint.
- Treatment protocols could involve the treatment of both peroneus brevis and longus trigger points simultaneously to improve the outcome on pain reduction and range of motion.

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Appendix A: Advert

RESEARCH

Have you ever hurt your Ankle?

If so please join in by participating in a clinical trial.

A Comparative Study Between Dry Needling Verses Shockwave Therapy on Peroneal Trigger Point in Patients with History of Chronic inversion Ankle Sprain

To participate – You must have experienced trauma to your ankle at least one time
– You must be between the ages of 18 – 35 years

If you are interested in participating in this research, come and visit me at the University of Johannesburg's Chiropractic day Clinic on Doornfontein Campus.

For more information on this research please contact me Robyn Miller on 0836594142

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Appendix B: STATKON Form

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CHIROPRACTIC

RESEARCH STATISTICS

This serves to confirm that the following student has discussed the research methodology with me as supervisor, and as such may consult with STATKON regarding the statistical analysis of the research.

Research title: A Comparative Study Between Dry Needling Verses Shockwave Therapy on Peroneal Trigger Points in Patients with History of a Chronic Inversion Ankle Sprain

Student name: Robyn Miller

Supervisor name: Dr C. Hay

Contact number: 011 559-6500

Signed: Date: 11 March 2019

This serves to confirm that the above indicated student has discussed the relevant statistical analysis of the data that will be obtained in their trial, with STATKON.

Statistician name: Jaclyn de Klerk

Signed: Date: 11 March 2019

Appendix C: Diagnostic criteria for chronic inversion ankle sprains (Anandacoomarasamy & Barnsley, 2005)

Inversion ankle sprains are usually perceived to be benign and self-limiting injuries, which usually respond well to conservative treatment. However, multiple studies have shown that it is not uncommon to have residual symptoms that can still be present months to years after the initial injury.

The residual symptoms may include:

- Mechanical instability.
- Intermittent swelling and stiffness.
- Accumulation of cartilage damage leading to early degenerative changes.
- Chronic complains of pain.
- Recurrent sprains.

Recurrent ankle sprains however, may lead to chronic ankle instability (Croy et al, 2012).

Chronic ankle instability may be characterized by:

- Recurrent instability episodes.
- Mechanical ligament laxity.
- Functional instability.
- Arthrokinematic changes.
- Balance deficits.

Appendix D: Diagnostic criteria for a myofascial trigger point (Sanz *et al.*, 2016)

There are two types of myofascial trigger points:

- Type one, is considered an active myofascial trigger point which can be related to spontaneous and continuous pain over time.
- Type two, is considered a latent myofascial trigger point, these trigger points do not induce spontaneous and continuous pain however, they may produce local or referred pain when direct pressure is applied to this point.

Myofascial trigger points may result in:

- A limited range of motion.
- Agonistic, antagonistic, and synergistic motor recruitment pattern alterations.

Diagnostic criteria for a myofascial trigger point:

- Palpation by physicians is a common method used for the diagnosis of myofascial pain in both clinical practice and research studies.
- The most reliable diagnostic procedures to determine a myofascial trigger point is identification of a taut band with pincer or snapping palpation.
- Reproduction of spontaneous pain during palpation.

Appendix E: Contra-indications to dry needling (Unverzagt *et al.*, 2015)

Dry needling therapy should be avoided in patients under the following circumstances

Absolute contraindications

1) A patient with a fear of needles
2) An unwilling patient
3) A patient who is unable or unwilling to give consent
4) A patient with a history of abnormal reaction to needling or injections
5) In a medical emergency
6) A patient who is on anticoagulant therapy, or who has thrombocytopenia
7) Into an area or limb with lymphoedema

Relative contraindications

1) Abnormal bleeding tendencies
2) A severely compromised immune system (eg. cancer, HIV, hepatitis, etc.)
3) Vascular disease
4) Diabetes mellitus
5) Pregnancy
6) Frail patients
7) Epilepsy
8) Allergy to metals or latex
9) Children
10) Individuals taking certain prescriptive medications (eg. significant mood altering medication, blood thinning agents, etc)
11) Extreme caution must be taken over the pleura and lungs, blood vessels, nerves, organs, joints, prosthetic implants and implantable electrical devices
12) Needling near a surgical site within four months of the surgical procedure
13) Decreased ability to tolerate the procedure

Appendix F: Contra-indications to shock wave therapy (Shockwave Therapy, 2019)

Shockwave is unsuitable in the following circumstances:

1. Pregnancy
2. Blood clotting disorders (including thrombosis)
3. If patient is on oral anti-coagulants
4. If patient has taken/received Steroid injection within 6 weeks
5. Pacemaker
6. Any malignancies over the area
7. Infection or skin abrasion at the treatment site
8. Minors under the age of 18 (except in the treatment of Osgood-Schlatter disease)
9. Over air-filled area such as the lungs or guts

Appendix G: Information letter

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CHIROPRACTIC
RESEARCH STUDY INFORMATION LETTER
REC 11.0

Good Day

My name is Robyn Miller **I WOULD LIKE TO INVITE YOU TO PARTICIPATE** in a research study on The Effects between Dry Needling and Shockwave Therapy on Peroneal Trigger Points in Patients with a History of Chronic Inversion Ankle Sprain.

Before you decide on whether to participate, I would like to explain to you why the research is being done and what it will involve for you. **I will go through the information letter with you and answer any questions you have.** This should take about 10 to 20 minutes. The study is part of a research project being completed as a requirement for a Master's Degree in Chiropractic through the University of Johannesburg.

THE PURPOSE OF THIS STUDY is to explore two different soft tissue modalities to the treatment of an active trigger points (knots) within the muscle of the anterior shin, to determine which treatment method is more effective, in a person who has experienced an injury to their ankle at least once throughout their life time.

Below, I have compiled a set of questions and answers that I believe will assist you in understanding the relevant details of participation in this research study. Please read through these. If you have any further questions I will be happy to answer them for you.

1. **WHAT CRITERIA DO I NEED TO MEET IN ORDER TO PARTICIPATE?** You must be between the ages of eighteen and thirty five years old. Both males and females are welcome to take part in this clinical trial. You must have experienced an injury to at least one of your ankles, which has been longer than two weeks ago and are not receiving any other form of treatment or rehabilitation for the injured ankle.

2. **DO I HAVE TO TAKE PART?** No, you don't have to. It is up to you to decide to participate in the study. I will describe the study and go through this information sheet. If you agree to take part, I will then ask you to sign a consent form.

3. **WHAT EXACTLY WILL I BE EXPECTED TO DO IF I AGREE TO PARTICIPATE?** Once you agree to participate, you will undergo a set of screening test, you will be required to give a brief history and a full physical examination will be done to ensure that you meet all the criteria that are required for this particular study. A few measurements will be taken of the ankle range of motion. Measurements of how tender the active trigger point (knot) in the anterior shin muscle will also be taken. You will be randomly placed in either group A or B to receive treatment. Group A will receive dry needling which will involve the insertion of a needle into the muscle in which the knot was found. Group B will involve the use of a shockwave machine, which will use waves that will send vibrations into the knot that was found in the muscle. Both of these treatment methods are used to break down the taut band (knot) which will in turn reduce the tenderness of the knot as well as stimulate blood flow to the area which will encourage healing.

4. **APPROXIMATELY HOW LONG WILL MY PARTICIPATION TAKE?** Your participation will take approximately three weeks for this particular study. This will involve seven visits that are spread out over the three week period, with two visits per week. There will be six treatment sessions, with measurements taken during the first, fourth and seventh visit. The initial visit will take one hour, whereas the follow up treatments will take thirty minutes each, with the final seventh visit taking ten minutes.

5. **WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY?** If you decide to participate, you are free to withdraw your consent at any time without giving a reason and without any consequences. If you wish to withdraw your consent, you should inform me as soon as possible.

6. **ARE THERE ANY OTHER POSSIBLE REASONS WHY MY PARTICIPATION MIGHT BE STOPPED?** It may happen that, due to your health or other treatments that you may receive or for safety reasons, I will need to stop your participation in this research. I will discuss this with you beforehand if it becomes necessary.

7. **IF I CHOOSE TO PARTICIPATE, WILL THERE BE ANY EXPENSES FOR ME, OR PAYMENT DUE TO ME?** You will not be paid to participate in this study and you will not bare any expenses.

8. **IF I CHOOSE TO PARTICIPATE, WHAT ARE THE RISKS INVOLVED?** Dry needling imposes the risk of post needling stiffness that could last up to two days, and is completely normal and common. Dry needling also imposes the risk of causing bruising in the area of the needle insertion but this is not as common. Contamination or infection also imposes a risk but all precautionary measures will be taken and this can be avoided by the use of latex gloves, sterile needles and cleaning the area and my hands thoroughly with a disinfectant. All used needles will be discarded in the sharps bins that are provided in each room in the clinic. Shockwave therapy imposes the risk of post treatment tenderness that could last up to two days over the treatment area. Both modalities are safe and risks are minor and uncommon, however both treatments are uncomfortable to endure. If you are experiencing any of the above mentioned risks for longer than the anticipated time period you should discuss it with me immediately.

IF I CHOOSE TO PARTICIPATE, WHAT ARE THE BENEFITS INVOLVED? Some of the benefits of this particular study are, a mild decrease in tenderness of myofascial trigger point and a possible increase in ankle range of motion, as well as to aid in the prevention of further ankle trauma. Possible benefits of this research will be to aid in determining the optimal treatment method for the treatment of ankle sprains. It also carries out the benefit of aiding further research. This study may not yield definite results.

9. **WILL MY PARTICIPATION IN THIS STUDY BE KEPT CONFIDENTIAL?** All reasonable efforts will be made to keep your personal information confidential and respect your right to privacy. This includes replacing your identifying personal information with a number that only I and my research supervisor will know. You will not be identified in any research reports that are published. Under some circumstances, such as when required to do so by a court of law, I may have to disclose your personal information. In addition, it may happen that your information will need to be reviewed by another organisation for quality assurance purposes. I will tell you about this if it happens.

10. **WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?** The results will be written into a research report that will be assessed. In some cases, results may also be published in a scientific journal. In either case, you will not be identifiable in any documents, reports or publications. You will be given access to the results of this if you would like to see them, by contacting me. If you decide to seek effective treatment post-trial, you will be offered the opportunity to do so.

11. **WHAT WILL YOUR RESPONSIBILITIES BE, AS THE RESEARCHER?** To ensure that the safety, dignity and confidentiality of my patients is maintained at all time throughout the study. To aid further research and to determine the best method for treating active myofascial trigger points of the peroneal muscles in people with a history of an inversion ankle sprain. It is my responsibility as the researcher to provide accurate and unbiased results relating to my study.

12. **WHO IS ORGANISING AND FUNDING THIS RESEARCH STUDY?** The study is being organised by me, under the guidance of my research supervisor at the Department of Chiropractic at the University of Johannesburg. This study has received funding from the University of Johannesburg.

13. **WHO HAS REVIEWED AND APPROVED THIS STUDY?** Before this study was allowed to start, it was reviewed in order to protect your interests. This review was done first by the Department of Chiropractic, and then secondly by the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg. In both cases, the study was approved.

14. **WHAT HAPPENS IF I GET INJURED DURING THE STUDY?** This research is not covered by the institutional insurance. In the event of an injury, you will be referred to the necessary medical professional however, this will be at your own cost.

15. **ARE THERE ANY CONFLICT OF INTERESTS PERTAINING TO THIS STUDY?** There are no conflict of interests held by anyone involved in this study.

16. **WHAT IF THERE IS A PROBLEM?** If you have any concerns or complaints about this research study, its procedures or risks and benefits, you should ask me. You should contact me at any time if you feel you have any concerns about being a part of this study. My contact details are:

Robyn Miller
Cell: 0836594142
Email: rmiller089@gmail.com

You may also contact my research supervisor:
Dr Caroline Hay
Email: carolineh@uj.ac.za

Or my co-supervisor:
Dr Fatima Ismail
Email: fismail@uj.ac.za

If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg:

Prof. Christopher Stein
Tel: 011 559-6564
Email: cstein@uj.ac.za

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given above.

Researcher:

Robyn Miller

Appendix H: Consent Form

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CHIROPRACTIC RESEARCH CONSENT FORM

A Comparative Study between Dry Needling Verses Shockwave Therapy on Peroneal Trigger Points in Patients with a History of Chronic Inversion Ankle Sprain

Please initial each box below:

☐ I confirm that I have read and understand the information letter dated 9 February 2019 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐ I agree to participate in the above research.

_____	_____	_____
Name of Participant	Signature of Participant	Date

_____	_____	_____
Name of Researcher	Signature of Researcher	Date

Appendix I: Case history research copy

Research Copy

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: _____

Patient _____ **File No. :** _____

Occupation: _____ **Age:** _____ **Sex:** _____

Student: _____ **Signature:** _____

FOR CLINICIAN USE ONLY:

Initial visit clinician: _____ **Signature:** _____;

Case History:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Examination:

Previous: UJ Other Current: UJ Other

X-ray Studies:

Previous: UJ Other Current: UJ Other

Clinical Path. Lab:

Previous: UJ Other Current: UJ Other

Case status:

PTT: Conditional: Signed off: Final sign out:

Recommendations:
Students case history:

1. **Source of History:** _____

2. **Chief Complaint in patients own words:**

_____

_____

_____

_____

_____

3. PRESENT ILLNESS/PRIMARY COMPLAINT

Location	
Onset	
Duration	
Frequency	
Pain Character	
Progression	
Aggravating Factors	
Relieving Factors	
Ass Signs & Symptoms	
Previous Occurrence	
Past Tx and Outcomes	

4. PAST HISTORY

General Health Status	
Childhood Illnesses	
Adult Illnesses	
Psychiatric Illnesses	
Accidents	
Traumatic Injuries	
Surgeries	
Hospitalizations	

5. ANY OTHER COMPLAINTS

_____

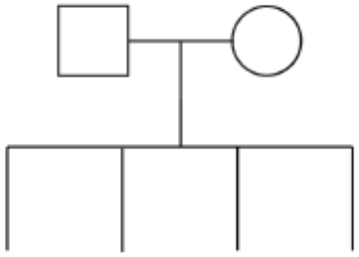
_____

6. CURRENT HEALTH STATUS & LIFESTYLE

Allergies	
Immunizations	
Screening Tests	
Environmental Hazards	
Safety Measures	
Progression	
Exercise and Leisure	
Sleep Patterns	
Diet	
Current Mediation	
Tobacco	
Alcohol	
Social Drugs	
Other	

7. FAMILY HISTORY

Diabetes Mellitus	
Heart Disease	
TB	
HBP	
Stroke	
Kidney Disease	
Cancer	
Arthritis	
Anaemia	
Headaches	
Thyroid Diseases	
Epilepsy	
Mental Illness	
Alcoholism	
Drug Addiction	
Other	



8. PSYCHOSOCIAL HISTORY

Home Situation	
Daily Life	
Important Experiences	
Religious Beliefs	
Other	

9. REVIEW OF SYSTEMS

General	
Skin	
Head	
Eyes	
Ears	
Noses / Sinuses	
Mouth / Throat	
Neck	
Breasts	
Respiratory	
Cardiac	
Gastrointestinal	
Urinary	
Genital/Sexual Function	
Vascular	
Musculoskeletal	
Neurological	
Hematological	
Endocrine	
Psychiatric	
Other	

Appendix J: Physical examination research copy

Research Copy

UNIVERSITY OF JOHANNESBURG

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

Underline abnormal findings in **RED** **Date:** _____

Patient:_____ **File No:** _____

Clinician:_____ **Signature:**_____

Student: _____ **Signature:** _____

VITAL SIGNS

Height	
Weight	
Temperature	
Heart Rate	
Pulse	
Respiratory Rate	

BLOOD PRESSURE

	Left	Right
Arms		
Legs		

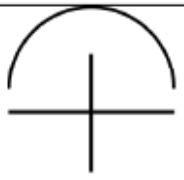
General Appearance

_____

_____

_____

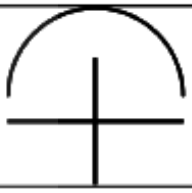
STANDING EXAMINATION

Minor's Sign	
Skin Changes	
Posture • Erect • Adams	
Romberg's Sign	
Pronator Drift	
Trendelenburg Sign	
Gait • Rhythm • Balance • Pendulousness • On toes • On heels • Tandem	
Half Squat	
Scapular Winging	
Muscle Tone	
Spasticity / Rigidity	
Chest measurement • Inspiration • Expiration	 _____ cm _____ cm
Visual Acuity	
Lumbar Spine ROM • Flexion (90°) • Extension (50°) • Lat. Flexion (30°) • Rotation (35°)	

SEATED EXAMINATION

Spinal Posture	
Head • Hair & Skin • Scalp • Skull • Face	
Eyes • Observation - Conjunctiva - Sclera - Eyebrows & Lids - Lacrimal Glands - Nasolacrimal Duct - Position - Alignment - Cornea / Lens • Corneal Reflex • Ocular Movements • Visual Fields • Accommodation • Ophthalmoscopy - Iris - Pupils - Red Reflex - Optic Disc - Macula - Vitreous - Lens	
Ears • Inspection - Auricle - Ear Canal - Drum • Auditory Acuity • Weber Test • Rinne Test	
Nose • External Inspection • Internal Inspection - Septum - Turbinate - Olfaction	
Sinuses • Tenderness • Transillumination	

SEATED EXAMINATION Cont.

Mouth & Pharynx • Lips • Buccal Mucosa • Gums & Teeth • Roof • Tongue - Inspection - Movements - Taste - Palpation • Pharynx – CN X	
TMJ • Inspection - ROM - Deviation • Palpation - Crepitus - Tenderness	
Neck • Posture • Size / Swellings • Scars • Discolorations • Hairline • Lymph Nodes • Tracheal Alignment • Thyroid & Carotids	
Cervical Spine ROM • Flexion (45°) • Extension (55°) • Lat. Flexion (40°) • Rotation (70°)	
Peripheral Vascular • Inspection - Pigmentation, Skin, Nailbeds, Hair loss • Palpation - Pulses, Lymph nodes, Skin Temp • Manual Compression • Retrograde Filling • Arterial Insufficiency • Allan's Test	

BREAST

Inspection • Skin • Size • Contour • Nipples • Arms Overhead • Hands Against Hips • Leaning Forward	
Palpation • Axillary Lymph Nodes • Breast • Breast tail	

THORAX – HEART AND LUNGS

Inspection • Skin • Shape • Respiratory Distress • Rhythm • Depth • Effort • Intercostal Retraction	
Palpation • Tenderness • Masses • Respiratory Expansion • Tactile Fremitus • JVP • PMI	
Percussion • Lungs (posterior) • Diaphgragmatic excursion • Kidney Punch	
Auscultation • Breath Sounds • Adventitious Sounds • Voice Sounds • Heart Auscultation • Heart Murmurs	

ABDOMINAL

Inspection • Skin • Umbilicus • Contour • Peristalsis • Pulsations • Hernias	
Auscultation • Bowel Sounds • Bruits	
Percussion • General • Liver • Spleen	
Palpation • Superficial Reflex • Cough • Light • Rebound Tenderness • Deep • Liver • Spleen • Kidneys • Aorta • Abdominal Masses • Shifting Dullness • Fluid Wave	
Acute Abdomen • Where pain began? • Moved to where? • Cough • Tenderness • Guarding / Rigidity • Rebound Tenderness	
Special Tests • Rovsing's Sign • Psoas Sign • Obturator Sign • Cutaneous Hyperaesthesia • Murphy's Sign • Rectal Examination	

MUSCULOSKELETAL

Shoulder • Observation - Skin - Symmetry • ROM - Glenohumeral - Scapulo-thoracic - Acromioclavicular - Elbow - Wrist		
Hip	Left	Right
• Flexion (90° / 120°)		
• Extension (15°)		
• Abduction (45°)		
• Adduction (30°)		
• Internal Rotation (40°)		
• External Rotation (45°)		
Knee	Left	Right
• Flexion (30°)		
• Extension (0° / 15°)		
Ankle	Left	Right
• Plantar Flexion (45°)		
• Dorsi Flexion (20°)		
• Inversion (30°)		
• Eversion (20°)		
Leg Length	Left	Right
• Apparent		
• Actual		

MENTAL STATUS

Appearance & Behavior • LOC • Posture • Motor Behavior • Dress, Grooming • Facial Expression • Affect	
Speed & Language • Quantity • Rate • Volume • Fluency • Aphasia (pm)	
Mood	
Memory • Orientation • Remote Memory • Recent Memory • New Learning Ability	
Higher Cognitive Function • Information • Vocabulary • Abstract Thinking	

CO-ORDINATION AND CEREBELLAR TESTING

Vertigo	
Ataxic Gait	
Nystagmus	
Intention Tremor	
Slurring/ Staccato Speech	
Hypotension	
Dysmetria (Point to point)	
Dysdiachokinesia	
Titubation	

CRANIAL NERVES

	Left	Right
CN I – Olfactory		
CN II – Optic		
CN III – Oculomotor		
CN IV - Trochlear		
CN V – Trigeminal • Motor • Sensory		
CN VI – Abducens		
CN VII – Facial • Motor • Sensory		
CN VIII - Vestibulocochlear		
CN IX – Glossopharyngeal		
CN X – Vagus		
CN XI – Spinal Accessory		
CN XII - Hypoglossal		

NEUROLOGICAL ASSESSMENT

DERMATOMES

	Left	Right
Cervical		
C2		
C3		
C4		
C5		
C6		
C7		
C8		
T1		
T2		
Lumbar		
T12		
L1		
L2		
L3		
L4		
L5		
S1		
S2		
S3		

REFLEXES

	Level	Left	Right
Cervical			
Biceps	C5		
Brachioradialis	C6		
Triceps	C7		
Lumbar			
Patella	L3 / L4		
Medial Hamstring	L5		
Lateral Hamstring	S1		
Tibialis Posterior	L4 / L5		
Achilles	S1 / S2		
Plantar Reflex			

NEUROLOGICAL ASSESSMENT

MYOTOMES

	Level	Left	Right
Cervical			
Neck Forward Flexion	C1 / C2		
Neck Lateral Flexion	C3		
Shoulder Elevation	C4		
Shoulder Abduction	C5		
Elbow Flexion	C5		
Elbow Extension	C7		
Elbow Flexion	C6		
Forearm Pronation	C6		
Forearm Supination	C6		
Wrist Extension	C6		
Wrist Flexion	C7		
Finger Flexion	C8		
Finger Abduction	T1		
Finger Adduction	T1		
Lumbar			
Hip Flexion	L1 / L2		
Knee Extension	L2 / L3 / L4		
Knee Flexion	L5 / S1		
Hip Internal Rotation	L4 / L5		
Hip External Rotation	L5 / S1		
Hip Adduction	L2 / L3 / L4		
Hip Abduction	L4 / L5		
Ankle Dorsiflexion	L4 / L5		
Ankle Plantar Flexion	S1 / S2		
Hallux Extension	L5		
Eversion	S1		
Inversion	L4		
Hip Extension	L5 / S1		

Appendix K: Lumbar regional research copy

Research Copy

UNIVERSITY OF JOHANNESBURG

CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION

LUMBAR SPINE

Date: _____

Patient: _____ **File No:** _____

Clinician: _____ **Signature:** _____

Student: _____ **Signature:** _____

OBSERVATION

Body Type	
Posture	
Muscle Tone	
Bony Contours	
Soft Tissue Contours	
Skin	
Fasciculations	
Scars	
Discolourations	
Step Deformities	
Plumb lines • Frontal plane • Sagittal Plane	

MYOFASCIAL – ACTIVE TRIGGER POINTS

	Left	Right
Quadratus Lumborum		
Erector Spinae		
Gluteus Maximus		
Gluteus Medius		
Gluteus Minimus		
TFL		
Piriformis		
Hamstrings		
Iliopsoas		

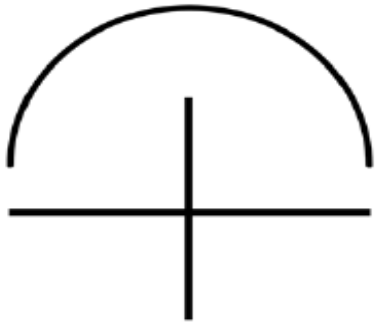
PALPATION

Iliac Crest	
Lumbar Spinous Process	
Muscle Bulk	
Sacro-iliac Joints	
Sacrum	

GAIT

Rhythm, Pendulousness	
On Toes (S1)	
On Heels (L4 / L5)	
Half Squat on One Leg	
Tandem Walking	

RANGE OF MOTION



NEUROLOGICAL ASSESSMENT

DERMATOMES

	Left	Right
T12		
L1		
L2		
L3		
L4		
L5		
S1		
S2		
S3		

NEUROLOGICAL ASSESSMENT

REFLEXES

	Level	Left	Right
Patella	L3 / L4		
Medial Hamstring	L5		
Lateral Hamstring	S1		
Tibialis Posterior	L4 / L5		
Achilles	S1 / S2		
Plantar Reflex			

REFLEX GRADING

- 4+ Very brisk, hyperactive. Perform ankle clonus.
- 2+ Average; normal
- 1+ Somewhat diminished; low normal.
- 0 No response

MUSCLE CIRCUMFERENCE

	Left	Right
Thigh	Cm	Cm
Calf	Cm	Cm

LEG LENGTH

	Left	Right
Actual	Cm	Cm
Apparent	Cm	Cm

NEUROLOGICAL ASSESSMENT

MYOTOMES

		Left	Right
Hip Flexion	L1 / L2		
Knee Extension	L2 / L3 / L4		
Knee Flexion	L5 / S1		
Hip Internal Rotation	L4 / L5		
Hip External Rotation	L5 / S1		
Hip Adduction	L2 / L3 / L4		
Hip Abduction	L4 / L5		
Ankle Dorsiflexion	L4 / L5		
Ankle Plantar Flexion	S1 / S2		
Hallux Extension	L5		
Eversion	S1		
Inversion	L4		
Hip Extension	L5 / S1		

MUSCLE GRADING

- 0 - No contraction detected
- 1 - Barely detectable flicker or trace of contraction
- 2 - Active movement with gravity eliminated
- 3 - Active movement against gravity
- 4 - Active movement against gravity and some resistance.

ABDOMINAL EXAMINATION

Observation	
Abdominal Reflexes	
Auscultation of Abdomen	
Auscultation of Groin	
Palpation of Abdomen	
Palpation of Groin	
Palpation of Abdominal Aorta	

PULSES

Femoral	
Popliteal	
Dorsalis Pedis	
Posterior Tibial	

ORTHOPAEDIC TESTS

	Left	Right
Standing		
Schober's Test		
Spinous Percussion		
Treadmill		
Minor's Sign		
Quick Test		
Trendelenburg's Test		
Seated		
Tripod Test		
Kemp's Test		
Valsalva Manoeuvre		
Supine		
SLR		
WLR		
Braggard's		
Bowstring's		
Sciatic Notch Pressure		
Sign of The Buttock		
Bilateral SLR		
Patrick Fabere's		
Gaenslen's Test		
"Squish" Test		
"Gapping" Test		
Gluteus Medius Stretch		
Thomas' Test		
Rectus Fem Contracture		
Hip Medial Rotation		
Psoas Test		
Lateral Recumbent		
Sacro-iliac Compression		
Ober's Test		
Femoral Nerve Stretch		
Prone		
Facet Joint Challenge		
Skin Rolling		
Erichsen's Test		
Sacro-Iliac Tenderness		
Pheasant's Test		
Gluteal Skyline		

NON-ORGANIC TESTS

	Left	Right
Pin-Point pain		
Axial Compression		
Trunk Rotation		
Burn's Bench Test		
Flip Test		
Hoover's Test		
Ankle Dorsiflexion Test		
Pin-Point Pain		

MOTION PALPATION

	Left	Right
T7 / T8		
T8 / T9		
T9 / T10		
T10 / T11		
T11 / T12		
T12 / L1		
L1 / L2		
L2 / L3		
L3 / L4		
L4 / L5		
L5 / S1		
Sacro-iliac Joint		

GENERAL COMMENTS:

Appendix L: Ankle regional research copy

Research Copy

UNIVERSITY OF JOHANNESBURG

UNIVERSITY OF JOHANNESBURG

CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION

FOOT AND ANKLE

Date: _____

Patient: _____ **File No:** _____

Clinician: _____ **Signature:** _____

Student: _____ **Signature:** _____

OBSERVATION (Standing and seated)

General	
Willingness to move	
Gait	
Posture	
Weight Bearing	
Balance	
Use of Support	
Proprioception	
Skin (Scars/Bruises)	
Muscle Atrophy	
Genu Varum/Valgum	
Tibial Torsion	
Arches of the foot	
Foot Deformities	

Common Deformities	
Claw Toes	
Rock Bottom Foot	
Exostosis	
Hallux Rigidus	
Hallux Valgus	
Hammer Toes	
Turf Toe	
Mallet Toes	
Morton's Foot	
Morton's Metatearsalgia	
Pes Cavus	
Pes Planus	
Equinus Deformity	

Palpation

	Left	Right
Anterior Aspect		
Medial Malleolus		
Tarsal Bones		
Posterior Tibial Pulses		
Lateral Malleolus		
Tarsal Bones • Cuneiform • Navicular • Talus • Cuboid		
Metatarsals/Phalanges		
Sinus Tarsi		
Inferior Tibiofibular joint		
Anterior Tibia		
Dorsalis Pedis Pulse		
Posterior Aspect		
Calcaneus		
Achilles Tendon		
Musculotendinous junction		
Plantar Surface		
Plantar muscles and fascia		
Sesamoid bones		

RANGE OF MOTION

	Left	Right
Weight Bearing		
Plantarflexion		
Dorsiflexion		
Supination		
Pronation		
Toe Extension		
Toe Flexion		

RANGE OF MOTION

	Active ROM		Passive ROM		Resisted Isometrics	
	Left	**Right**	**Left**	**Right**	**Left**	**Right**
Non Weight Bearing						
Knee Flexion						
Knee Extension						
Plantarflexion (50°)						
Dorsiflexion (20°)						
Supination (45° to 60°)						
Pronation (15° to 30°)						
Toe Extension • MTP (40°)/ PIP (0°)/ DIP (30°) • Great toe MTP (70°)/ IP (0°)						
Toe Flexion • MTP (40°)/ PIP (35°)/ DIP (30°) • Great toe MTP (45°)/ IP (90°)						
Toe Adduction						
Toe Abduction						

JOINT PLAY

	Left	**Right**
Talocrural		
Long Axis Extension		
Anteroposterior glide		
Subtalar Joint		
Talar Rock		
Side Tilt Medial /Lateral		
Midtarsal Joints		
Anteroposterior glide		
Rotation		
Tarsometatarso joints		
Anteroposterior glide		
Rotation		
Metatarsophalangeal & Interphalangeal joints		
Long Axis Extension		
Anteroposterior glide		
Lateral glide		
Rotation		

MYOFASCIAL

	Left	**Right**
Tibialis Anterior		
Tibialis Posterior		
Fibularis Longus		
Fibularis Brevis		
Fibularis Tertius		
Gastrocnemius		
Soleus		
Popliteus		

SPECIAL TESTS

	Left	**Right**
Tests for Alignment		
Subtalar Neutral		
Leg-Heel Alignment		
Forefoot to Heel		
Coleman Block Test		
Too Many Toes Sign		
Test for tibial torsion		
Feiss line		
Flexible / Rigid Flat Foot		
First Ray Alignment		
Tests for Ligamentous Instability		
Anterior Drawer		
Talar Tilt		
Klieger Test		
Syndesmosis Tests		
Squeeze Test		
Point Palpation		
Dorsiflexion Maneuver		
Dorsiflexion/Compression		
Heel Thump		
Achilles Tendon Tests		
Thompson Test		
Hoffa's test		
Tests for Nerve Entrapment		
Tinel's at the ankle		
Duchenne's		
Morton Squeeze Test		
Vascular Tests		
Homan's Sign		
Buerger's Sign		
Trendelenburg's Test		
Capillary Refill		

Appendix M: SOAP notes research copy

Research Copy

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC
SOAP NOTE

Patient:	Visit Number:
File Number:	Student:
Date:	Clinician:
S:	O:
A: Differential Diagnosis / ICD-10 Code	P: Procedure Codes
Home Advice:	Comments:

Patient:	Visit Number:
File Number:	Student:
Date:	Clinician:
S:	O:
A: Differential Diagnosis / ICD-10 Code	P: Procedure Codes
Home Advice:	Comments:

Appendix N: NPRS (Bolton & Wilkinson, 1998)

Name: _____

File Number: _____

Date: _____

Place a mark on the pain scale below that represents your pain at this point in time. On a scale of zero to ten, zero meaning no pain and ten meaning the worst possible pain. The middle of the scale describes moderate pain. A rating of two or three describes a mild pain and a rating of seven or higher describes a severe pain.

Visit 1:

No pain	Mild pain			Moderate pain			Sever pain			
0	1	2	3	4	5	6	7	8	9	10

Visit 4:

No pain	Mild pain			Moderate pain			Sever pain			
0	1	2	3	4	5	6	7	8	9	10

Visit 7:

No pain	Mild pain			Moderate pain			Sever pain			
0	1	2	3	4	5	6	7	8	9	10

Appendix O: Procedure for dry needling of the peroneal muscles (Travell & Simmons, 1999)

Peroneus longus trigger point can be located along the upper belly, approximately 2-4 cm distal to the head of fibula. Peroneus brevis trigger point can be located mid-muscle belly, usually each side and deep to peroneus longus tendon at the junction of middle and lower 3rd of the leg.

1. Patient is placed in the side lying position, with the effected side up.
2. Pillows are placed behind the patients head and one placed between the patients knees.
3. Locate the fibula's head and the lateral malleolus, divide the leg into thirds by drawing lines between those two anatomical landmarks into thirds.
4. Locate the neck of the fibula, draw a line 2-3 cm below the neck of the fibula, anything above that line is considered a danger zone as the common peroneal nerve runs around the neck of the fibula.
5. Clean the area to be needled, fingers and kidney dish with an alcohol swabs.
6. Open needles and place into the kidney dish.
7. Put on the latex gloves and clean gloves with alcohol swab, clean the area again with alcohol swabs.

For peroneus longus

8. Using flat palpation to palpate the muscle against the fibula.
9. Remove plastic lid from the tube while keeping the needle inside the tube.
10. Place the needle over the trigger point with the tube, tap the top of the needle until a superficial penetration is achieved with the needle.
11. Remove the tube while maintaining flat palpation and soft tissue control, and push the needle deeper to acquire the trigger point until a twitch response is felt.
12. Needle is directed straight down towards fibula, avoiding common peroneal nerve.

For peroneus brevis

13. Remove plastic lid from the tube while keeping the needle inside the tube.
14. Place the needle over the trigger point with the tube, tap the top of the needle until a superficial penetration is achieved with the needle.
15. Remove the tube while maintaining flat palpation and soft tissue control, and push the needle deeper to acquire the trigger point until a twitch response is felt.
16. The needle is angled 45° laterally away, under the peroneus longus tendon, needle down towards fibula.

Appendix P: Procedure of shockwave therapy on the peroneal muscles (Frairia & Berta, 2011)

Settings for shockwave therapy:

- A low to medium shock pressure with less shocks have been shown to induce tissue proliferation rather than destruction. A setting of: power 60-90mj between 1-2 bars, frequency 10-16Hz, shocks 1000 for 1 spot and 4000 for larger area should be used to induce tissue healing.

1. The patient is placed in the side lying position with the affected side facing up.
2. A pillow is placed behind the patients head and between their knees to ensure comfort is maintained throughout the procedure.
3. Palpation is done of the peroneal muscles against the fibula to locate the trigger point.
4. The machine should be set.
5. Ultra sound gel is placed over the treatment area and over the head of the shockwave machine.
6. The head of the machine is placed over the trigger point with slight downwards pressure until the tip is has reached the line on the head.
7. Press the start button on the applicator to begin delivering shocks for treatment to commence.

Appendix Q: Permission to treat at UJ

23 July 2019

Robyn Miller (**Student #** 201423254)
University of Johannesburg
Faculty of Health Sciences

Dear Robyn Miller

PERMISSION TO CONDUCT RESEARCH AT THE UNIVERSITY OF JOHANNESBURG

The proposal and research instruments for the research study titled *A Comparative Study between Dry Needling Versus Shockwave Therapy on Peroneal Trigger Point in Patients with a History of Ankle Trauma* were reviewed. Full permission **is granted to the conduct this study at UJ.**

Sincerely

Dr Carol Nonkwelo
Executive Director: Research and Innovation
Email: cnonkwelo@uj.ac.za

Appendix R: Trial registration

4/4/2019 Gmail - Registration on www.pactr.org

Gmail ROBYN MILLER <rmiller089@gmail.com>

Registration on www.pactr.org

noreply@samrc.ac.za <noreply@samrc.ac.za> Sat, Mar 9, 2019 at 4:04 PM
To: rmiller089@gmail.com
Cc: pactradmin@mrc.ac.za

Dear Robyn Miller,

Thank you for your registration on .

Your registration has been successful. You are now able to submit trials and view progress status.

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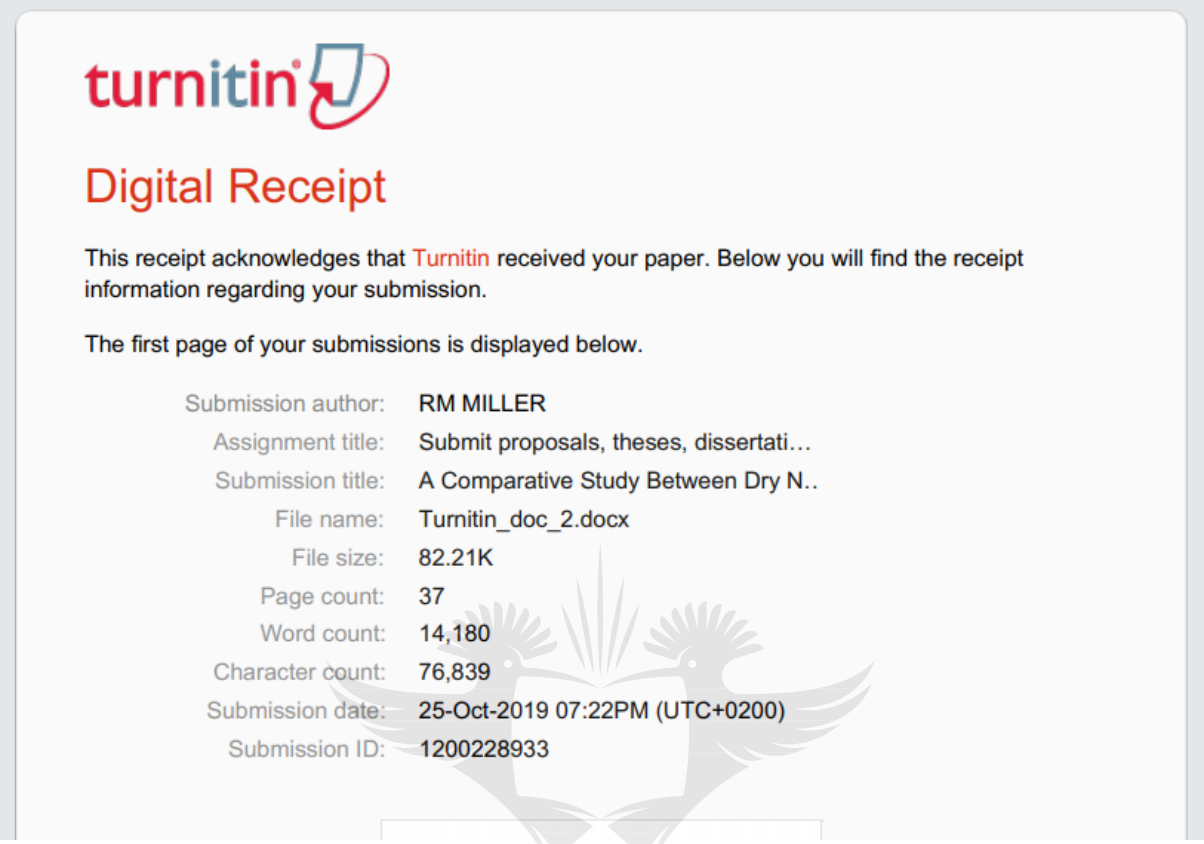
Regards

Registry Administration
Cochrane South Africa
South African Medical Research Council

Appendix S: Turnitin report



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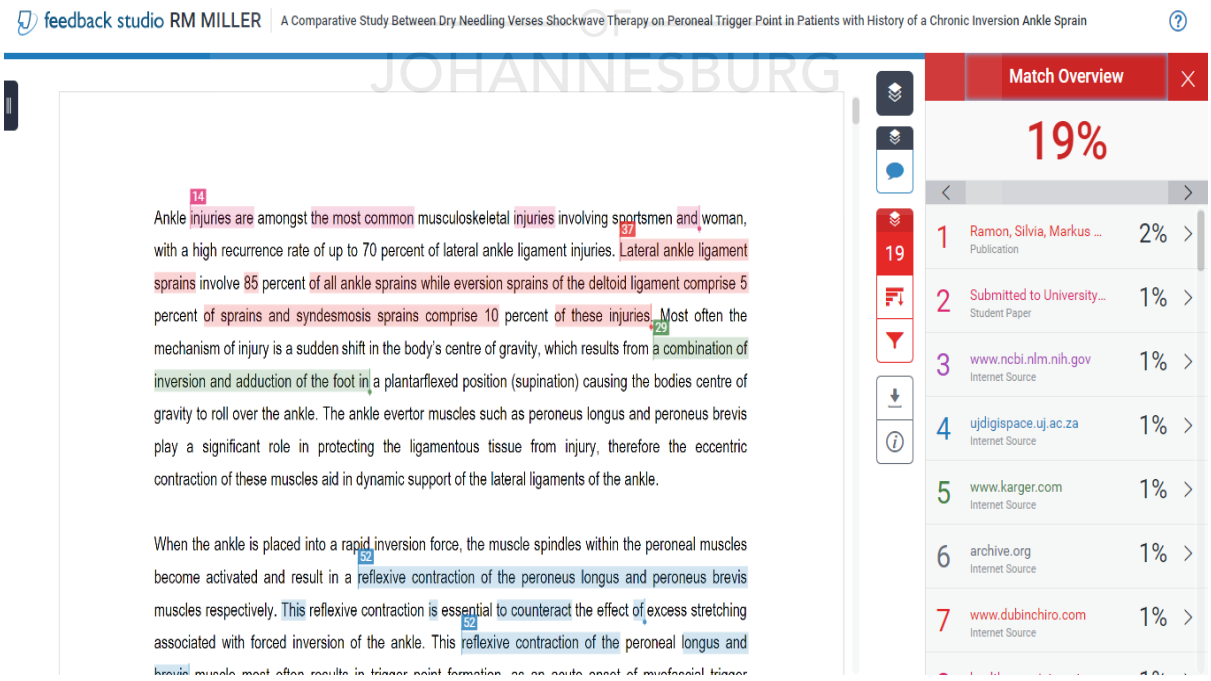
Submission author:	RM MILLER
Assignment title:	Submit proposals, theses, dissertati…
Submission title:	A Comparative Study Between Dry N..
File name:	Turnitin_doc_2.docx
File size:	82.21K
Page count:	37
Word count:	14,180
Character count:	76,839
Submission date:	25-Oct-2019 07:22PM (UTC+0200)
Submission ID:	1200228933



feedback studio RM MILLER | A Comparative Study Between Dry Needling Verses Shockwave Therapy on Peroneal Trigger Point in Patients with History of a Chronic Inversion Ankle Sprain

Ankle injuries are amongst the most common musculoskeletal injuries involving sportsmen and woman, with a high recurrence rate of up to 70 percent of lateral ankle ligament injuries. Lateral ankle ligament sprains involve 85 percent of all ankle sprains while eversion sprains of the deltoid ligament comprise 5 percent of sprains and syndesmosis sprains comprise 10 percent of these injuries. Most often the mechanism of injury is a sudden shift in the body's centre of gravity, which results from a combination of inversion and adduction of the foot in a plantarflexed position (supination) causing the bodies centre of gravity to roll over the ankle. The ankle evertor muscles such as peroneus longus and peroneus brevis play a significant role in protecting the ligamentous tissue from injury, therefore the eccentric contraction of these muscles aid in dynamic support of the lateral ligaments of the ankle.

When the ankle is placed into a rapid inversion force, the muscle spindles within the peroneal muscles become activated and result in a reflexive contraction of the peroneus longus and peroneus brevis muscles respectively. This reflexive contraction is essential to counteract the effect of excess stretching associated with forced inversion of the ankle. This reflexive contraction of the peroneal longus and

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Appendix T: Ethical clearance letter

FACULTY OF HEALTH SCIENCES
RESEARCH ETHICS COMMITTEE

NHREC Registration: REC 241112-035

ETHICAL CLEARANCE LETTER
(RECX 2.1)

Student/Researcher Name	Miller, R	Student Number	201423254
Supervisor Name	Dr C Hay	Co-Supervisor Name	Dr F Ismail
Department	Chiropractic		
Qualification	367		
Research Title	A Comparative Study between Dry Needling versus Shockwave Therapy on Peroneal Trigger Point in Patients with History of a Chronic Inversion Ankle Sprain		
Date	27 May 2019	Clearance Number	**REC-01-23-2019**

Approval of the research proposal with details given above is granted, subject to any conditions under 1 below, and is valid until 23 May 2020.

1. **Conditions*:**
Registration of the research on the South African National Clinical Trial Register.

2. **Renewal:**
It is required that this ethical clearance is renewed annually, within two weeks of the date indicated above. Renewal must be done using the Ethical Clearance Renewal Form (REC 10.0), to be completed and submitted to the Faculty Administration office. *See Section 12 of the REC Standard Operating Procedures.*

3. **Amendments:**
Any envisaged amendments to the research proposal that has been granted ethical clearance must be submitted to the REC using the Research Proposal Amendment Application Form (REC 8.0) prior to the research being amended. Amendments to research may only be carried out once a new ethical clearance letter is issued. *See Section 13 of the REC Standard Operating Procedures.*

4. **Adverse Events, Deviations or Non-compliance:**
Adverse events, research proposal deviations or non-compliance must be reported within the stipulated time-frames using the Adverse Event Reporting Form (REC 9.0). *See Section 14 of the REC Standard Operating Procedures.*

The REC wishes you all the best for your studies.

Yours sincerely.

Prof. Christopher Stein
Chairperson: REC
Tel: 011 559 6564
Email: cstein@uj.ac.za

Appendix U: HDC clearance letter

FACULTY OF HEALTH SCIENCES

HIGHER DEGREES COMMITTEE

HDC-01-16- 2019

27 May 2019

TO WHOM IT MAY CONCERN:

STUDENT: **MILLER, R**
STUDENT NUMBER: **201423254**

TITLE OF RESEARCH PROJECT: A Comparative Study between Dry Needling versus Shockwave Therapy on Peroneal Trigger Point in Patients with History of a Chronic Inversion Ankle Sprain

DEPARTMENT OR PROGRAMME: CHIROPRACTIC

SUPERVISOR: Dr C Hay **CO-SUPERVISOR:** Dr F Ismail

The Faculty Higher Degrees Committee has scrutinised your research proposal and concluded that it complies with the approved research standards of the Faculty of Health Sciences; University of Johannesburg.

The HDC would like to extend their best wishes to you with your postgraduate studies

Yours sincerely,

Prof S Nalla
Chair: Faculty of Health Sciences HDC
Tel: 011 559 6258
Email: shahedn@uj.ac.za